SAN FRANCISCO AREA NETWORK

PRELIMINARY WATER QUALITY STATUS REPORT

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<u>San Francisco Area Network</u>
Eugene O'Neill National Historic Site
Fort Point National Historic Site
Golden Gate National Recreation Area
John Muir National Historic Site
Muir Woods National Monument
Pinnacles National Monument
Point Reyes National Seashore
Presidio of San Francisco

ABSTRACT

Although the San Francisco Bay Network (SFAN) Water Quality Monitoring Program is integrated with the larger SFAN Vital Signs Monitoring Program, it is coordinated and funded separately; therefore a separate (though comparable) approach was determined to be necessary. This document augments existing portions of the SFAN long-term monitoring plan (Phases I & II). It facilitates the water quality monitoring plan development process (including protocols) by identifying potential watersheds to be monitored, describing the status of existing data, providing a preliminary review of data, and reviewing current issues & priorities (i.e., monitoring needs). Primary SFAN issues include agricultural operations (dairy and beef cattle ranching, vegetable farming, viniculture, mariculture), recreational use (beaches, stable operations, dog walks), erosion and sedimentation, and water supply (flooding, overwithdrawal). Primary SFAN needs include data analysis and feedback and prioritization of management strategies (based on data analysis). Work within SFAN parks is underway to address these issues and needs. Phase III of the long-term water quality monitoring plan will outline how this work will continue in the future.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

List of Tables

List of Acronyms

ASBS	Area of Special Biological Significance
AWAG	Alhambra Watershed Action Group
BMP	Best Management Practice
BO	Biological Opinion
BU	Beneficial Use
CCCR	Central California Coast Biosphere Reserve
CCSF	City and County of San Francisco
CDFG	California Department of Fish and Game
COE	(Army) Corps of Engineers
CSBP	California Stream Bioassesment Protocol
CSRP	Coho and Steelhead Restoration Project
CWA	Clean Water Act
CWRCB	California Water Resources Control Board
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethylene
DMMO	Dregded Materials Management Office
EBRPD	East Bay Regional Park District
ENSO	El Niño Southern Oscillation
EUON	Eugene O'Neill National Historic Site
FIB	Fecal Indicator Bacteria
FOPO	Fort Point National Historic Site
GFNMS	Gulf of the Farallones National Marine Sanctuary
GGNRA	Golden Gate National Recreation Area (public acronym)
GMA	General Minerals Analysis
GOGA	Golden Gate National Recreation Area (official government acronym)

GPRA	Government Performance and Results Act

List of Acronyms (continued)

HUC	Hydrologic Unit Code
I&M	Inventory & Monitoring
IPM	Integrated Pest Management
IQR	Interquartile Range (statistical value)
MMC	Marine Mammal Center
MMWD	Marin Municipal Water District
MPA	Marine Protected Areas
MPN	Most Probable Number (using multiple tube method for fecal/total coliform enumeration)
MUWO	Muir Woods National Monument
NAWQA	National Ambient Water Quality Assessment
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Association
ONRW	Outstanding Natural Resource Water
PCB	Polychlorinated Biphenyls
PINN	Pinnacles National Monument
PORE	Point Reyes National Seashore (official government acronym)
PRBO	Point Reyes Bird Observatory
PRES	Presidio of San Francisco
PRNS	Point Reyes National Seashore (public acronym)
QAPP	Quality Assurance Protection Plan
RCD	Resource Conservation District
RWQCB	Regional Water Quality Control Board
SFAN	San Francisco Bay Area Network
SFPUC	San Francisco Public Utilities Commission
STORET	Storage and Retrieval (EPA's Water Quality database)
TBAG	Tomales Bay Agricultural Group
TBSTAC	Tomales Bay Shellfish Technical Advisory Committee
TBWC	Tomales Bay Watershed Council
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TSS	Total Suspended Solids
TTS	Turbidity Threshold Sampling
UCB	University of California-Berkeley
UNECSCO	United Nations Educational, Scientific, and Cultural Organization
USEPA	United States Environmental Protection Agency
USFWS	Unites State Fish and Wildlife Service
USGS	United States Geological Survey
UWP	Urban Watershed Project
WRD	Water Resources Division (National Park Service)

PURPOSE & NEED

The San Francisco Area Network (SFAN) is in the process of developing long-term monitoring plans for its parks. Plans will include protocol narratives for each priority ecosystem indicator. Development of the plans (including the water quality monitoring plan) has followed guidance in a May 2002 Memorandum to NPS Regional Inventory & Monitoring (I&M) Coordinators: "Development of Park Vital Signs Monitoring Programs and Integration of Water Quality Monitoring" (Appendix C). The memo outlines a three-phase approach for developing monitoring plans that would track trends in environmental conditions throughout the National Parks. In addition to the general I&M guidance, the water quality monitoring plan follows specific planning process steps outlined by the National Park Service's Water Resources Division (Irwin, 2004) and (Penoyer, 2004).

The focus of this document is to summarize existing data and information related to park water resources in order to provide a background for developing the long-term water quality monitoring protocol (Phase III). This document will facilitate the Phase III development process by identifying potential watersheds to be monitored, describing the status of existing data (including a preliminary water quality data analysis), and reviewing current issues & priorities (i.e., monitoring needs). Much of this information was gained in preparation for the Network Water Quality Planning Meetings ("scoping meetings") and from meeting discussions.

<u>Water Quality Planning Meeting Purpose, Structure, and Content</u>

Meetings were held for JOMU/EUON, GOGA/MUWO, PINN, PORE, and PRES. The approach (consistent with WRD guidance) was to hold Water Quality Planning Meetings for each park with the objective of obtaining input from individual parks towards development of the long-term water quality monitoring plan. The desired outcome was to gather park information related to water quality, identify and prioritize water quality issues, and identify the resources available to monitor. The meeting also provided an opportunity to introduce the I & M Water Quality Monitoring Program and plan development process to those unfamiliar with it. Park staff, local agencies, watershed groups, and university staff were invited to participate. However, outside entities were not actively sought unless parks requested it or already had well-established relationships with them. A future meeting including all entities involved in monitoring within the parks is proposed. In addition, a group of technical experts will be convened to serve as the peer review team for the Water Quality Monitoring Plan (Phase III).

The meetings included a presentation followed by an open discussion. The presentation outlined the program initiative including enabling legislation, NPS Director's Orders and the GPRA goal (reduction in the percentage of impaired waters and preservation of pristine waters). The objectives for the long term monitoring program and required parameters to monitor were presented. Program objectives included: 1) Allow characterization of existing water quality, 2) identify changes or trends in water quality in order to detect problems, 3) make informed management decisions, 4) monitor corrective actions, 5) convince other agencies and individuals to make decisions that benefit the parks, and 6) satisfy legal mandates. The presentation also outlined beneficial uses of streams and monitoring activities within the park and sparked discussion of water quality issues. The discussions were guided by specific questions related to land use and water quality. A list of discussion questions for each park is included in Appendix E. This document is not intended to be an exhaustive review of water quality data but an overall review of park issues, status of monitoring projects, and projected monitoring needs.

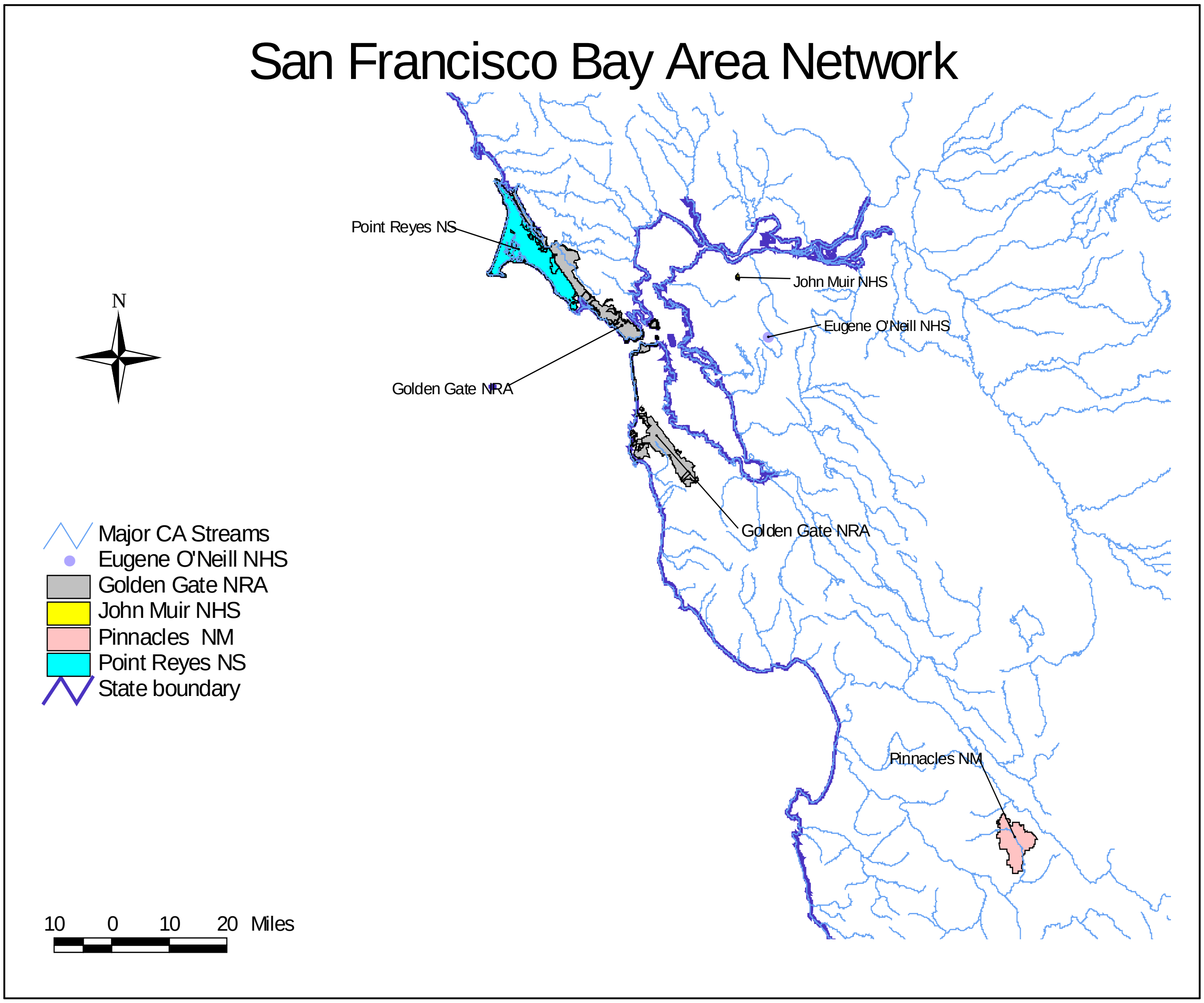

Figure 1. Map of San Francisco Bay Area Network Parks (MUWO, PRES, and FOPO are included within GOGA).

INTRODUCTION

<u>Overview of Aquatic Resources</u>

The SFAN is located within two subregions of USGS Water Resource Region 18. These include Subregion 1805 – San Francisco Bay and Subregion 1806-Central California Coastal. PORE, GOGA, PRES, MUWO, FOPO, JOMU, and EUON fall within subregion 1805 while PINN falls within Subregion 1806. JOMU is within the 644 mi^2 Suisan Bay HUC (hydrologic unit code). Parts of GOGA and EUON are within the 1200 mi^2 San Francisco Bay HUC. PORE and portions of GOGA are within the 339 mi^2 Tomales-Drakes Bay HUC. Portions of GOGA are also within the San Francisco Coastal South HUC (256 mi^2).

The SFAN has many unique aquatic resources that are significant in an ecological and economic context. Aquatic Resources in the SFAN include streams, bays, estuaries, lagoons, lakes, reservoirs, freshwater and estuarine marshes, and seeps. The combination of marine and freshwater aquatic systems within the network supports a variety of threatened and endangered species including the California freshwater shrimp (*Syncharis pacifica*), coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorhynchus mykiss*), the California red-legged frog (*Rana aurora draytonii*), tidewater goby (*Eucyclogobius newberryi*), Tomales roach (*Lavinina symmetricus ssp 2*), and Northwest Pond Turtle (*Clemmys marmorata mormorata*). Commercial operations include a significant herring fishery in Tomales Bay and oyster growing in Tomales Bay and Drakes Estero.

Watershed conditions vary from coastal watersheds in wilderness areas to an urbanized watershed managed as a public water supply. Lobos Creek in the Presidio of San Francisco (PRES) is the only free-flowing (above ground) creek in the city. Land uses within the more rural watersheds include agricultural and commercial (e.g., beef and dairy cattle ranching, viniculture, oyster harvesting, and equestrian) operations as well as predominantly wilderness areas.

The Mediterranean climate of the San Francisco Bay Region sustains wet winters followed by dry summer months. The hydrologic systems are very flashy, with high runoff in the winter, and very low to intermittent flow dominating summer conditions. In response to flashy hydrologic conditions and the highly active geologic processes associated with the San Andreas Fault, stream channels are typically dynamic. Chalone Creek in PINN includes a highly mobile sand bed that typically dries in the summer months. Watersheds within JOMU and the developed portions of GOGA are highly altered by development and urbanization. These systems are highly confined/constrained, with natural processes engineered out of the stream system. Watersheds within the Marin and San Mateo County portions of GOGA, as well as PORE, watersheds are fairly stable and functional, supporting threatened coho salmon and steelhead trout. Stream systems in these areas have been impacted by historic or current agricultural activities as well as more dispersed development.

Several NPS efforts to improve water resources within SFAN are underway. The Redwood Creek watershed and MUWO are currently the focus of a variety of activities including watershed planning, transportation planning, water quality and water rights investigations, sensitive species monitoring, aquatic system and riparian restoration, invasive non-native plant removal and habitat restoration, and GIS mapping of all watershed features. Similar activities are occurring throughout the network though on a smaller scale. Several stream restoration projects are on going at PORE including bank stabilization and dam removal projects. Restoration efforts for Chalone Creek (PINN) and its floodplain have also been initiated. Streambank restoration (including removal of invasive plants, erosion control, and bank stabilization) is proposed along Franklin Creek (JOMU), and a feasibility study for a wetland restoration is being conducted at EUON. Tidal wetland restoration efforts are on going at PORE, GOGA, and PRES. Wetlands inventories and functional assessments are being conducted at GOGA (funded by the I &M program), as well as PORE (funding through NPS-WRD). In addition, a watershed project aimed at “daylighting” Tennessee Hollow Creek (PRES) and improving its ecological integrity is underway. Restoration efforts have primarily focused on the protection and restoration of natural physical processes and habitat known to benefit T&E aquatic species as well as water quality.

<u>Water Quality Criteria</u>

“What constitutes good water quality depends on the type of water body and the type of ecosystem it supports or the intended use of the water” (Stafford & Horne, 2004).

All of the park units except PINN are regulated by the San Francisco Bay Regional Water Quality Control Board (RWQCB, part of the State Water Resources Control Board). PINN is within the Central California Coast RWQCB. Management criteria for water bodies within the state of California are established by these Regional Boards. Through Basin Plans the Regional Boards have set numerical and narrative objectives for surface waters (Tables 1, 2, and 4) (California Regional Water Quality Control Board, 1995). Several parameters (e.g., nitrates, phosphates) that are considered of importance to existing SFAN park water quality monitoring programs do not have criteria established by the Regional Board. A separate document, the Ocean Plan, was produced by the State Board to regulate ocean waters (State Water Resources Control Board, 2001). The Basin Plans also outline the beneficial uses assigned to each stream that is a significant surface water feature. The combined beneficial uses of the streams within the network are listed in Table 3. Basin plans establish beneficial uses and set numeric and narrative criteria to meet those surface water use objectives.

Table 1. Numerical objectives for physical parameters in surface waters in the San Francisco Bay Area.

Parameter	Water Quality Objective
Dissolved Oxygen tidal waters	Downstream of Carquinez bridge 5.0 mg/L minimum Upstream of Carquinez bridge 7.0 mg/L minimum
Dissolved Oxygen non-tidal waters	Cold water habitat 7.0 mg/L minimum Warm water habitat 5.0 mg/L minimum
pH	Less than 8.5 and greater than 6.5
Un-ionized ammonia	Annual Median 0.025 mg/L as N Maximum Central Bay 0.16 mg/L as N Maximum Lower Bay 0.4 mg/L as N

Table 2. General numeric objectives for biological parameters in surface waters in the San Francisco Bay Area.

Beneficial Use	Fecal Coliform (MPN/100mL)	Total Coliform (MPN/100mL)
Contact recreation	Log mean < 200 90^{th} percentile < 400	Median < 240 No sample > 10,000
Non-contact recreation	Mean < 2000 90^{th} percentile < 4000	
Shellfish harvesting	Median < 14 90^{th} percentile < 43	Median < 70 90^{th} percentile < 230

Table 3. Beneficial uses of streams within the SFAN.

Acronym	Definition
AGR	Agricultural Supply
COLD	Cold Freshwater Habitat
COMM	Commercial and Sport fishing
EST	Estuarine Habitat
FRSH	Freshwater Replenishment
GWR	Groundwater recharge
IND	Industrial Service Supply
MAR	Marine Habitat
MIGR	Fish Migration
MUN	Municipal Supply
NAV	Navigation
PROC	Industrial Process Supply
RARE	Preservation of Rare and Endangered Species
REC 1	Contact Water Recreation
REC2	Non-contact Water Recreation
SHELL	Shellfish Harvesting
SPWN	Fish Spawning
WARM	Warm freshwater habitat
WILD	Wildlife Habitat

Table 4. Additional Water Quality Criteria for Contact Recreation (REC 1)

	Marine Water	Fresh Water
Total Coliform		
Single Day Sample	10,000	10,000
30 Day Average	1,000	1,000
E. coli		
Single Day Sample	235	235
30 Day Average	126	126
Enterococcus		
Single Day Sample	104	61
30 Day Average	35	33
Fecal coliform		
Single Day Average	400	400
30 Day Average	200	200

Significant Waters

Significant freshwater bodies have not yet been officially designated for the State of California. However, freshwater streams within SFAN support federally threatened steelhead trout (*Oncorhynchus mykiss*) and coho salmon (*Oncorhynchus kisutch*). Spawning of these species has been documented in several SFAN watersheds (four in GOGA legislative boundary and two in PORE). Additional watersheds within PORE and GOGA have potential to support these species.

There are several significant and unique coastal waters within the San Francisco Bay Region. Recognizing the extraordinary significance and exposure to threats in the region, the UNESCO (United Nations Educational, Scientific, and Cultural Organization) Man in the Biosphere program designated the Central California International Biosphere Reserve in 1988, encompassing six of the eight parks and including coastal waters. The California coast is only one of five areas of eastern boundary coastal upwelling oceanic currents worldwide and the only one in North America.

In 2000, the State of California drafted a MPA (Marine Protected Area) plan encompassing ASBS (Area of Special Biological Significance) as primary reserve areas. In response, a variety of stakeholders are restoring MPAs and reserves for the purpose of marine species protection. The State Water Resources Control Board (part of the California Environmental Protection Agency) has established four Areas of Special Biological Significance (ASBS) within the legislative boundaries of the SFAN parks. These include the Point Reyes Headlands, Bird Rock, Double Point, and the James Fitzgerald Marine Preserve. The Point Reyes Headlands, Bird Rock, and Double Point are managed by PORE. Duxbury Reef (adjacent to the PORE legislative boundary) is also an ASBS. These areas were chosen through a nomination process based primarily on habitat quality and limited to coastal areas; inland areas have not yet been assessed. The procedure for this nomination process is in the California Ocean Plan (2001) developed by the State Water Resources Control Board. Other “significant waters” (e.g., Outstanding Natural Resource Waters, or ONRW) in the state are not located within SFAN. Lake Tahoe is the only ONRW in the state.

In addition to the above designations and associated marine protection, PORE and GOGA are part of the Gulf of the Farallones National Marine Sanctuary. A plume of warmer freshwater exiting the San Francisco Bay extends out into the Gulf of the Farallones. These nutrient rich waters support an abundant and diverse fauna.

Clean Water Act Section 303d Impaired Waters

Water bodies within and adjacent to NPS lands have been identified as impaired. The NPS is currently working with the state and local agencies to develop and implement monitoring and enhancement efforts to address impairment issues. The San Francisco Bay RWQCB has identified Tomales Bay (PORE/GOGA) and its tributaries (Lagunitas Creek and Walker Creek) as impaired by fecal coliform (pathogens), sediment, and nutrients (Table 5). In addition, Tomales Bay and Walker Creek are also listed as impaired by Mercury. In 2000, Marin County announced a fish consumption advisory for Tomales Bay due to mercury bioaccumulation associated with an abandoned mercury mine in the Walker Creek watershed.

Health concerns have also arisen due to contamination of shellfish with pathogenic bacteria. SFAN and PORE staff have collaborated with the RWQCB regarding monitoring of indicator bacteria in Olema Creek (tributary to Lagunitas). The RWCB recently completed a final TMDL project report for pathogens in Tomales Bay (Ghodrati, 2004). Required monitoring (by NPS and others) for the Tomales Bay Pathogen TMDL program will include monthly monitoring plus five consecutive weeks of monitoring during the winter rainy season. NPS has also monitored sediment and nutrients in Olema Creek. Sediment, nutrient, and mercury TMDL projects have not yet been completed for Tomales Bay (Table 1.5).

The RWQCB has established a timeline for development of Total Mean Daily Loads (TMDLs) associated with the highest priority impairment listings (Table 4). Not all impaired (Section 303d listed) water bodies currently have TMDL projects. For a complete listing of impaired water bodies and a map of current projects see Appendix A of the SFAN Preliminary Water Quality Status Report in Appendix 6 of the overall Phase III study plan.

In addition to Tomales Bay, GOGA lands are adjacent to (and in some areas, include) portions of Central San Francisco Bay. Current TMDL projects in the Bay include Mercury and PCBs. Potential sources of mercury include industrial and municipal point sources, resource extraction, and atmospheric deposition. Sources of PCBs are unknown (non-point sources). Other pollutants listed by the Regional Water Quality Control Board include exotic species and selenium; USEPA has also added several pollutants to the list including pesticides chlordane and DDT (see Appendix A for full listing). The Regional Board developed a conceptual approach for developing sediment TMDLs (Napolitano et al., 2003) in San Francisico Bay Area streams and nutrient TMDLs in San Francisco Bay area water bodies (Krottje and Whyte, 2003).

A portion of the San Francisquito Creek watershed is located within GOGA's newly acquired South lands. This creek is listed as sediment impaired. The type and extent of impairment is unknown at this point. SFAN recently began baseline water quality monitoring (including sediment) in West Union Creek, one of the San Francisquito Creek tributaries.

All urban creeks in the San Francisco Bay area are considered impaired by diazinon. Potential for contamination by this pesticide exists in all urban areas. The most urbanized areas within NPS lands include water bodies in the Presidio (Lobos Creek, Dragonfly Creek, Tennessee Hollow), JOMU (Franklin Creek), and GOGA (Milagra Creek, Calera Creek, Sanchez Creek, San Pedro Creek). With the exception of the Presidio creeks, significant portions of these watersheds are located outside NPS land. City water treatment plants monitor Diazinon; data is available from the Baker Beach Treatment plant that tests Lobos Creek. Recent data has not indicated contamination by diazinon. A Final Project Report for Diazinon and Pesticide-Related Toxicity in Bay Area Urban Creeks was also completed (Johnson, 2004).

Table 5. Impaired water bodies in SFAN (from the 2002 303d list)

Water body	Park Unit	Pollutant
Coyote Creek	GOGA	Diazinon
Lagunitas Creek	PORE, GOGA	Pathogens, Sediment, Nutrients
Richardson Bay*	GOGA	High Coliform, Mercury, PCBs, Pesticides, Exotic Species
San Francisco Bay*	GOGA, PRES	Mercury, PCBs, Nickel, Pesticides, Exotic Species, Dioxin, Selenium
San Francisco Bay Urban Creeks	GOGA, PRES, JOMU	Diazinon
San Francisquito Creek	GOGA	Diazinon, Sediment
San Pedro Creek	GOGA	High Coliform
Tomales Bay	PORE, GOGA	Pathogens, Sediment, Nutrients, Mercury

**See Appendix A for details*

Table 6. RWQCB TMDL Project Schedule as of 11-19-04

Water body	Park Unit	Pollutant	Project Report Completion	Regional Board Adoption Date
Lagunitas Creek	PORE, GOGA	Sediment	Dec. 2006	Feb. 2008
San Francisco Bay	GOGA, PRES	PCBs	Nov. 2003	Sept. 2005
San Francisco Bay	GOGA, PRES	Legacy pesticides	Dec. 2007	Dec. 2008
San Francisco Bay	GOGA, PRES	Mercury	June 2003	Sept. 2004
San Francisco Bay	GOGA, PRES	Pesticide Toxicity	Oct. 2006	Aug. 2007
San Francisco Bay	GOGA, PRES	Nickel	Dec. 2004	Aug. 2005
SF Bay Urban Creeks	GOGA, PRES	Diazinon	Mar. 2004	June 2005
San Francisquito Creek	GOGA	Sediment	Dec. 2005	Dec. 2006
Tomales Bay	GOGA, PORE	Mercury	Aug. 2006	Dec. 2007
Tomales Bay	GOGA, PORE	Pathogens	Feb. 2004	Mar. 2005
Tomales Bay	GOGA, PORE	Sediment	Dec. 2007	Dec. 2008

SFAN PARK WATER RESOURCE BACKGROUND AND SCOPING

Eugene O'Neill NHS (EUON)

The 13.2 acre EUON is located 26 miles east of San Francisco on the west side of Danville, in Contra Costa County. This cultural resource park overlooks the San Ramon Valley. The park was established by Public Law in 1976: "in commemoration of the contributions of Eugene O'Neill to American drama", and furthermore, "as a memorial to Eugene O'Neill and a park for the performing arts and related educational programs" (Public Law 94-539). Las Trampas Regional Wilderness Area (administered by the East Bay Regional Park District) surrounds EUON on three sides.

Surface Hydrology & Water Resources

Eugene O'Neill NHS is located within the approximately 150 sq. mile Walnut Creek watershed; Walnut Creek flows north into Suisun Bay. Tributaries to Walnut Creek include Lafayette Creek, Las Trampas Creek, Tice Creek, San Ramon Creek, and Pine Creek. No creeks flow through the park. An unnamed tributary to San Ramon Creek flows behind the EUON property (about 1/8 mi north of the park boundary). Water from an adjacent stock pond occasionally overflows into a culvert that flows into this tributary. This former stock watering pond is located behind the EUON property on land owned by the East Bay Regional Park District (EBRPD); however, through an agreement with EBRPD, EUON manages the approximately two-acre pond. Damming of a small spring-fed canyon formed the pond.

Through a separate agreement with the EBRPD, EUON also manages the springs and associated water tanks that are located on the adjacent Las Trampas Regional Wilderness. Though the springs are not used for drinking water by NPS, they were the water source for the O'Neill house. Major aquifers beneath the eastern sides of Las Trampas Ridge feed the springs (East Bay Regional Park District et al., 1993).

In addition to the springs and former stock pond, a small ephemeral unnamed stream (with an eroded canyon) flows behind the park headquarters. This stream flows into the tributary of San Ramon Creek just north of the park. During dry periods, all water in the park and the surrounding Las Trampas Regional Wilderness Area originates from spring flow.

Within the Las Trampas Regional Wilderness, Bollinger Creek is the most prominent water body. This creek is one of four major drainages in Las Trampas Regional Wilderness (East Bay Regional Park District et al., 1993). It is a tributary to Walnut Creek.

Beneficial Uses and Aquatic Life

Since there are no major water resources at EUON, the San Francisco Bay Regional Water Quality Control Board (RWQCB) does not include them in their Basin Plan listing of stream beneficial uses. However, the listed beneficial uses for Walnut Creek include cold water habitat (COLD), fish migration (MIGR), fish spawning (SPWN), warm water habitat (WARM), and wildlife habitat (WILD). Potential beneficial uses include contact (REC-1) and non-contact (REC-2) recreation. The springs managed by EUON are no longer used as drinking water supply (MUN – municipal and domestic supply) but are available for fire management purposes.

Past Inventories/Monitoring

Water Quality & Flow Monitoring
The springs were tested for indicator bacteria from 1976-1995 (Glenn Fuller, pers. comm). They are located on Regional Park Property but are managed by NPS. The springs were developed by a French drain system and water is stored in three Redwood storage tanks

The East Bay Regional Park District monitored Bollinger Creek in 1992 and 1993. Sediment, bacteria, and nutrients are known concerns. Information regarding additional monitoring in watersheds surrounding the park is included in the WRD Baseline Water Quality Data Inventory and Analysis Report (2002) for EUON.

According to the WRD Baseline Water Quality Data Inventory and Analysis report, no monitoring stations were located within park boundaries. There is a lack of recent data for all parameters measured in the Study Area. Potential pollution sources include those typical of an urban area surrounding rural areas (e.g., stormwater runoff and wastewater discharges).

Weather Monitoring
As part of the SFAN weather monitoring program, SFAN staff installed a Davis Instruments (Weather Link) weather station on the EUON property in November 2002. The station is located between the Maintenance building and the stock pond. It records wind speed and direction, rainfall, relative humidity, barometric pressure and temperature. Weather data will ultimately be stored in the SFAN weather database that is currently under development.

Land Use & Water Quality Issues

The streambanks of the unnamed ephemeral creek behind the EUON HQ building are very steep. Erosion is a concern since the stream flows immediately behind the historic O'Neill orchards and swimming pool. This could potentially impact the historical integrity of the site. The stream does not pose an immediate threat (due to erosion) but the opportunity to prevent a future threat should be addressed.

Priorities & Meeting Summary for EUON

There are no significant natural resources, nor are there significant issues at this time. Although water quality monitoring is not a major component necessary for park management, streambank erosion is a concern. Park staff experienced in erosion control will conduct a site visit to evaluate erosion issues related to the gully/canyon between the park HQ and the EUON swimming pool and orchards.

A Humboldt State graduate student conducted a preliminary study to determine the feasibility of restoring a wetland in the location of the stock pond (i.e., removing the dam to allow creation of a spring-fed wetland) (Morales, 2004).

John Muir NHS (JOMU)

John Muir NHS is approximately 20 miles northeast of San Francisco and is located on the south side of Martinez, in the Alhambra Valley of Contra Costa County. It consists of three separate, non-contiguous properties. The park was established in 1964 to preserve the 8.8 acre area including the John Muir house "as a public memorial to John Muir in recognition of his efforts as a conservationist and a crusader for national parks and reservations" (Public Law 88-547). In 1988, Mount Wanda (named after Muir's eldest daughter) was added to the park. It includes 326 acres of undeveloped woodland and grassland. Residential areas surround it. John Muir NHS also recently acquired the Muir gravesite tract along Alhambra Creek (1.3 acres).

Surface Hydrology & Water Resources

John Muir NHS is located within the 16.5 mi^2 Alhambra Creek watershed in northwestern Contra Costa County. Two sub-watersheds are located within the park: Franklin Creek and Strentzel Creek (a.k.a. Sub-watershed No. 1167). Alhambra Creek itself flows past the Muir gravesite, but is not located within the park boundaries. Alhambra Creek (a.k.a Arroyo del Hambre) flows north into the Carquinez Strait between Suisan Bay and San Pablo Bay north of San Francisco Bay.

The 5 mi^2 Franklin Creek watershed supports an intermittent stream that flows behind the Muir house (just west of the house). Franklin Creek joins Alhambra Creek just downstream of the Muir House in the town of Martinez. It begins in the hills overlooking Martinez and flows primarily eastward towards Alhambra Creek.

Strentzel (Canyon) Creek begins in the hillslopes of Mt. Wanda, and flows through a ranch (the Strain Ranch) and past the Muir gravesite before meeting with Alhambra Creek. The Ranch will become park property in the future. Some tributaries of the creek are spring-fed; however, the mainstem is ephemeral and only flows during storm events. The watershed area is less than 1 sq. mile. Approximately half of the watershed is outside JOMU boundaries.

Beneficial Uses and Aquatic Life

The Alhambra Creek watershed is not included in the San Francisco Bay RWQCB's 1995 Basin Plan. According to park and network staff, potential beneficial uses of Franklin Creek include municipal and domestic supply, wildlife habitat, non-contact recreation, and possibly coldwater habitat (Franklin Creek). Steelhead trout have been observed in the mainstem (Alhambra Creek) but are not known to have existed in Franklin Creek. Significant gravel beds are present in Franklin Creek; these would provide spawning areas for salmonids. However, there are several migration barriers within the stream and it is not certain whether the stream meets coldwater temperature requirements for the fish.

In a memo to the San Francisco Bay RWQCB, network staff asked that, since it flows directly into the Bay-Delta, the Alhambra Creek watershed be recognized and listed for its beneficial uses. These include both potential and expected existing uses including: potential cold freshwater habitat; potential fish migration; municipal and domestic water supply; habitat for rare and threatened species; potential contact recreation; non-contact recreation; potential fish spawning; warm freshwater habitat; wildlife habitat. Other changes and additions were requested for streams throughout the network (see the memo in Appendix B).

The primary beneficial uses of Strentzel Canyon are non-contact recreation and wildlife habitat. With the exception of a few stock watering ponds, it is not used as water supply. Fire roads provide fire protection as well as access for hikers.

Past Inventories/Monitoring

<u>Water Quality & Flow Monitoring</u>
No water quality monitoring had been conducted in the streams within JOMU boundaries until 2004. The SFAN water quality specialist initiated baseline monitoring in Franklin Creek and Strentzel Canyon in January 2004 (non-storm event) and captured a storm event in these same watersheds in late February. Measured parameters included pH, temperature, dissolved oxygen, specific conductance, conductivity, and salinity as well as laboratory-analyzed parameters including total suspended solids (TSS), nitrate, ammonia, and fecal/total coliforms. Baseline water quality monitoring (including flow measurements) will continue quarterly through summer 2004. Monitoring after that date will depend upon methods outlined in the Phase III Long-Term Water Quality Monitoring Plan (expected completion September 2004).

According to the WRD Baseline Water Quality Data Inventory and Analysis report, no monitoring stations were located within park boundaries. No long-term stations were found within the study area (larger area including the park). There were two monitoring stations located on Franklin Creek , one upstream and one downstream of the park. However, there was only one sampling event (one observation) in 1953.

A staff plate and datalogging water level monitor were installed on Franklin Creek in August 2003. Flow measurements were taken in Franklin Creek in conjunction with macroinvertebrate sampling in August 2003 and baseline water quality monitoring in January and February 2004. Water samples were also collected in April aand August when flow was minimal. In addition to hydrologic monitoring, SFAN staff conducted fish and benthic macroinvertebrate surveys in the 200 m reach of Franklin Creek flowing through the John Muir homesite. Only stickleback fish have been found; results of macroinvertebrate (aquatic bioassessment) sampling in 2003 and 2004 are not yet available. A continuous temperature logger was installed in Franklin Creek in the summer (2004). Hereafter, the temperature logger will be deployed in the late spring/early summer and removed before the first storms in the late fall/winter.

Local watershed groups and county entities have conducted water quality monitoring in Franklin Creek and Alhambra Creek, but outside JOMU boundaries. Contra Costa County has conducted aquatic bioassessment in Franklin Creek downstream of JOMU. The Friends of Alhambra Creek (a volunteer/stewardship group) have also monitored water quality (core parameters plus fecal coliforms and nutrients) in Franklin Creek downstream of JOMU. This group has also conducted monitoring of Alhambra Creek (that flows past the John Muir gravesite). Information from these groups can be utilized to help understand conditions within the park boundaries and throughout the watershed. In addition to the “Friends”, the Alhambra Action Group (formerly the Alhambra Creek Watershed Planning Group) is a local advocacy group. Additional information about the watershed and the “Group’s” objective’s is contained in the Alhambra Creek Watershed Management Plan (Alhambra Creek Watershed Planning Group, 2001). Data from monitoring conducted by these groups can be utilized to help understand conditions within the park boundaries and throughout the watershed. Additional past monitoring is documented in the NPS Water Resources Division’s (WRD) Baseline Water Quality Data Inventory and Analysis Report for JOMU (1998).

Weather Monitoring

SFAN staff installed a Davis Instruments (Weather Link) weather station on Mount Wanda in November 2002. It records wind speed and direction, rainfall, relative humidity, barometric pressure and temperature. Weather data will ultimately be stored in the SFAN weather database that is in development.

Land Use & Water Quality Issues

The potential or existing issues in the JOMU watersheds include pollution by fecal coliforms, nutrients, and sediment and impacts of flooding. Cattle grazing occurs on the south side of the Strentzel Canyon sub-watershed (outside JOMU boundaries) and in the upper reaches of Franklin Canyon. Monitoring by the Friends of Alhambra Creek has indicated the presence of high numbers of fecal coliforms. Additional water quality results will help determine the extent of runoff (or direct inputs) of animal wastes into the streams. Other potential sources of pollutants in Franklin Creek include illegal dumping, highway runoff, horse operations, a nursery, and residential septic systems. In the Strentzel Creek watershed, sediment is of particular concern. Sources include erosion from cattle grazing, a breached dam, fire roads, and degradation of the channel itself. Due to excessive erosion and the associated reduction of channel capacity, flooding frequently occurs in the Strentzel Lane neighborhood (across from the Strain Ranch) and at the Muir gravesite. A project initiated by Contra Costa County is currently underway to increase channel capacity and reduce the velocity of Strentzel Canyon in its downstream section.

Priorities & Meeting Summary for JOMU

Due to the small size of this park, determining the priorities was relatively straightforward. As stated previously, significant erosion (and associated water quality and flooding issues) exist for Strentzel Creek. Franklin Creek is also in need of monitoring due to high fecal coliform numbers and the potential for salmonid habitat. Franklin Creek is an urban, very visible creek and therefore, provides an opportunity for park personnel to set an example for the community. Priorities include the following:

1. Work towards stabilization of Strentzel Creek and developing an understanding of watershed issues.
2. Coordinate with local watershed groups on monitoring activities.
3. Address fecal coliform concerns on Franklin Creek and differentiate sources.
4. Monitor in Franklin Creek to achieve high standards of water quality; lead the way and set an example for the community.
5. Identify and evaluate current data from other organizations

Recommendations for Future Monitoring

Based on hydrology and watershed area, one proposed strategy is to focus on Franklin Creek for long-term monitoring and Strentzel Creek for synoptic, event-based sampling. The sampling strategy for Strentzel Creek will focus on sediment while the strategy for Franklin Creek will focus on fecal coliforms. However, both sediment and fecal coliforms (as well as the core parameters) will be monitored in both sub-watersheds. Any long-term monitoring activities will be coordinated with the Friends of Alhambra Creek group and the Alhambra Watershed Action Group (AWAG). The existing Alhambra Creek Watershed Management plan will be consulted in order to monitor Franklin Creek and Strentzel Canyon within the framework of the plan.

A Watershed Management Plan for the Strentzel Creek Watershed is being developed by Chad Moore (NPS Physical Scientist). That plan will incorporate the Alhambra Creek Watershed Management Plan. Some preliminary recommendations include: installing a staff plate in Stretnzel Creek just upstream of the Strain Ranch and conducting intensive sediment sampling. It has been recommended that water samples from within and outside park boundaries be collected and analyzed for total suspended solids, turbidity, and conductivity (total dissolved solids). Comparing contributions from within and outside the park boundaries may help differentiate sediment sources and can also assist public relations between the park and the community since flooding is a significant issue in the Strentzel Lane neighborhood.

Golden Gate NRA (GOGA) and Muir Woods NM (MUWO)

Golden Gate National Recreation Area was founded in 1972 “in order to preserve for public use and enjoyment certain areas of Marin and San Francisco Counties possessing outstanding natural, historic, scenic, and recreational values” (Public Law 92-589). The park’s enabling legislation also states that management of the park “shall utilize the resources in a manner which will provide for recreational and educational opportunities consistent with sound principles of land use planning and management.” In addition, the Secretary (of the Interior) shall “preserve the recreation area, as far as possible, in its natural setting, and protect it from development and uses which would destroy the scenic beauty and natural character of the area.” Additional information can be found in the Natural Resources Section of the Resources Management Plan (NPS, 1999).

Muir Woods NM was established in 1905 “to protect the grove of coast redwoods because the trees are of scientific value because of the primeval character of the forest, the age and size of the trees (and) their location near centers of population and instruction”. Muir Woods was purchased from the Mount Tamalpais Water Company by William Kent in 1905. It was proclaimed a National Monument in 1908 (the first National Monument created by land donated by a private individual).

The natural resources of MUWO are essentially managed by GOGA; therefore, GOGA and MUWO were included together in the water quality planning meetings. In addition, although the Presidio is considered part of GOGA, it is managed separately under the Presidio General Management Plan (1994) and jointly by NPS and the Presidio Trust. Therefore, it is discussed in a separate section of this document.

Many of the lands managed by Golden Gate NRA were historically military areas and emplacements. The lands stretch in a long, narrow band along or near the coast. To the north and south of the Golden Gate, parklands are numerous and are located in Marin County (north of the Golden Gate), San Francisco and San Mateo Counties (south of the Golden Gate) as well as within San Francisco Bay itself. Northern lands of GOGA (lands north of Bolinas-Fairfax Road) are managed by PORE and will be discussed in that section of this document.

The park comprises approximately 75,000 acres of coastal lands (approximately 550 acres of which is MUWO). North of the Golden Gate, GOGA managed lands include Oakwood Valley, Wolfback Ridge, Stinson Beach, Muir Beach , the Marin Headlands, the Mill Valley Air Force Station, Point Bonita, and Fort Baker. Located within the city and County of San Francisco are Alcatraz Island, Fort Point NHS (FOPO), Fort Miley, Fort Funston, Cliff House/Sutro Properties, Fort Mason, Ocean Beach, and the San Francisco Maritime NHP. All of these "original lands" were acquired in 1972 with some being added in 1974. In addition, the South Lands (San Mateo County) were acquired beginning in 1980 with Sweeney Ridge (est. 1,500 acres), Milagra Ridge (240 acres), and the San Francisco Watershed Lands (est. 20,000 acres). The SF Watershed lands are located within the GOGA authorized boundary but managed by the County of San Francisco; public access is restricted. In 1992, Phleger Estate, an estimated 1,000 acres, was acquired. The 105-acre Mori Point (located near Pacifica) was acquired in 2002. These lands and the many beaches and watersheds within their boundaries will be discussed further in the following paragraphs.

Surface Hydrology & Water Resources

GOGA/MUWO encompasses many small, coastal watersheds. Seven major watersheds are located within the parks' legislative boundaries. These include (from north to south): Lagunitas Creek, Olema Creek, Redwood Creek, Tennessee Creek (a.k.a. Elk Creek), Rodeo Creek, San Francisco Watershed Lands, and West Union Creek in San Mateo County (NPS, 1999). Lagunitas and Olema Creeks are located within park areas managed by Pt. Reyes National Seashore (to the north and bordering GOGA) and will be discussed later in this document. In addition to freshwater streams and ponds, there are also numerous springs, lagoons, and wetlands. Saltwater areas are also included within the park as the legislative boundary extends ¼ mile offshore into the Pacific Ocean. In addition, all military forts have surrounding waters within their boundary. The Draft Water Resources Management plan (Golden Gate NRA, 1990) provides further descriptions of the water resources within the park.

<u>Marin Headlands/Stinson Beach/Bolinas Lagoon Areas</u>
Redwood Creek is the largest drainage (7.5 mi^2) in GOGA/MUWO. Its headwaters flow from the south side of Mount Tamalpais. The creek flows through Mount Tamalpais State Park, through Muir Woods NM, past the Banducci Property, under Highway 1 and into the Pacific Ocean at Muir Beach. The largest tributary to upper Redwood Creek is Bootjack Branch (1.96 mi^2), followed by Fern Creek (1.11 mi^2) and Kent Creek (0.99 mi^2). There are seven other minor tributaries (including Spike Buck Creek, Rattlesnake Creek, and Camino del Canyon) in what is considered "upper" Redwood Creek.

In addition, Green Gulch (1.26 mi^2) is the largest tributary to lower Redwood Creek (Lehre, 1974). Green Gulch and another tributary (often referred to as Golden Gate Dairy Tributary) join the creek less than ½ mile upstream of the mouth. The area near the mouth of the creek is known historically as *Big Lagoon.* Planning for restoration of this lagoon is underway. Observed (measured) flows in Redwood Creek range from intermittent up to 2,150 cfs (cubic feet per second) (USGS peak flow data Station No. 11460150 1962-1973). More recently, flows have been calculated by consultants using hydraulic models.

Tennessee (Valley) Creek, a 2.4 mi^2 drainage area, is located in a Valley north of Rodeo Valley and South of Redwood Creek. Its headwaters are located entirely within GOGA. It generally flows from east to west and empties into the Pacific Ocean at Tennessee Cove. The creek is dammed near the Cove and at the upstream portion of one of its tributaries (Backdoor Creek). Another dam along one of its tributaries (Haypress) was recently removed.

Oakwood Valley flows near the eastern boundary of GOGA in a watershed adjacent to the Tennessee Valley watershed. Nyhan Creek flows very near Tennessee Valley Creek but on the opposite side of the drainage divide. Oakwood Valley flows north and east on GOGA land until it joins Nyhan Creek just outside the park boundary. Nyhan Creek (an approximately 2 mi^2 watershed) then flows east into Coyote Creek and then to Richardson Bay. Coyote Creek drains the town of Mill Valley and the eastern slopes of Mount Tamalpais. Coyote Creek is listed as impaired by Diazinon. Richardson Bay is also on the Section 303d list for being impaired by several pollutants (Table 5).

Rodeo Lagoon drains an approximately 4.4 mi^2 area in the southernmost portion of the Marin Headlands. The mouth of Rodeo Lagoon is located at Rodeo Beach/Fort Cronkhite. The lagoon is infrequently connected with the ocean; it is not commonly affected by tidal influence. Rodeo (Valley) Creek headwaters are located entirely within GOGA lands (Marin Headlands). Rodeo Valley is also known as Gerbode Valley (and contains a groundwater reserve of that name). Rodeo Creek flows more or less from east to west and includes a North Fork and South Fork. Developments located within the drainage include park housing, a stable operation, and Fort Cronkhite.

Numerous small drainages (less than 1.5 mi^2) are also present in the Marin County lands. These drainages include (from south to north) Cold Stream, Lone Tree Creek, and Webb Creek (from south to north) south of the town of Stinson. These drainages flow directly into Pacific Ocean.

The approximately 1.4 mi^2 Easkoot Creek watershed is located in the town of Stinson (and parallel to Stinson Beach) and empties into Bolinas Lagoon before reaching the Ocean. Restoration of this creek (including salmonid habitat improvement and improved channel configuration) is underway. Fitzhenry Creek and Black Rock Creek are the two main branches of Easkoot Creek. Other small Bolinas Lagoon drainages (flowing from Bolinas Ridge) include: Stinson Gulch, McKinnan Gulch, Morses Gulch, Audubon Canyon and Pike County Gulch. Two additional drainages from Bolinas Ridge are Wilkins Gulch and Lewis Gulch. However, these northernmost Bolinas Lagoon drainages are technically outside the GGNRA managed boundary (they are north of the Bolinas-Fairfax Road). A good review of several of these watersheds is included in *The Climate and Hydrology of the Golden Gate National Recreation Area* (Lehre, 1974).

South Lands (San Mateo County)

West Union Creek, located in the recently acquired Phleger Estate in central San Mateo County, drains an approximately 5 mi^2 area. The creek's headwaters are located within Phleger Estate and it flows south through the adjacent Huddart County Park in the town of Woodside. There are two minor (unnamed) tributaries to the creek within Phleger Estate. Another tributary, McGarvey Gulch, flows into West Union Creek near the boundary between Phleger Estate and Huddart County Park. West Union is a tributary to Bear Creek that flows into San Francisquito Creek that ultimately empties into San Francisco Bay northeast of Palo Alto and Stanford. San Francisquito Creek is on the Section 303d list for impairment by sedimentation/siltation. As a Bay Area urban creek, it is also listed as impaired by the pesticide diazinon.

The San Francisco (Peninsula) Watershed Lands (including the 8 mi^2 San Pedro Creek watershed) are also located within the authorized boundary of the GOGA South Lands in northwestern San Mateo County (South of San Francisco). A scenic easement and a scenic and recreation easement including these lands was established through a four-party agreement including the U.S. Department of Interior, SFPUC (San Francisco Public Utilities Commission), Caltrans, and San Mateo County. GOGA does not currently manage these lands. The headwaters of San Pedro Creek are located in San Pedro Valley Park (a San Mateo County Park). These include the Middle Fork (including one tributary) and South Fork (including the tributary Brooks Creek) of San Pedro Creek. The Middle Fork and South Fork are spring-fed and join near the County Park boundary. The mainstem then flows northwest through the Linda Mar neighborhood in the town of Pacifica and out to the Ocean. San Pedro Creek is on the 303d list for impairment by high coliforms.

Additional small (less than one square mile) drainages exist in the GOGA South Lands. These include (from north to south) Milagra Creek (bordering Milagra Ridge), Sanchez Creek (in Mori Point), and Calera Creek (with headwaters in Sweeney Ridge). These are very small watersheds that flow through predominantly residential areas in the town of Pacifica. All creeks are channelized/concrete lined and/or culverted for significant portions of their reaches. The Sharp Park Golf Course borders Sanchez Creek/Mori Point.

Beaches and Saltwater Resources

Several beaches are located within GOGA authorized boundaries. South of the Golden Gate these include the long narrow strand of Ocean Beach (west side of San Francisco) and Aquatic Park (north of San Francisco).
Named beaches north of the Golden Gate include Horsehoe Bay (at Fort Baker), Rodeo Beach (at Fort Cronkhite), Tennessee Cover (at the mouth of Tennessee Valley), and Muir Beach (at the mouth of Redwood Creek and in the town of Muir Beach. Further north along Hwy. 1 (Coast Highway) is Stinson Beach (in the town of that name) south of Bolinas Lagoon. This beach is the northernmost beach managed by GOGA.

Beneficial Uses and Aquatic Life

In its Basin Plan, the San Francisco Bay RWQCB lists Beneficial Uses for the Pacific Ocean, Bolinas Lagoon, Redwood Creek, and Rodeo Creek. Beneficial Uses for the Pacific Ocean and Bolinas Lagoon include commercial and sport fishing, marine habitat, fish migration, navigation, preservation of rare and endangered species, contact recreation, non-contact recreation, shellfish harvesting, fish spawning and wildlife habitat. The Basin Plan also lists industrial service supply and navigation as beneficial uses for the Pacific Ocean. Listed beneficial uses for Redwood Creek include agricultural supply, coldwater habitat, freshwater replenishment, municipal supply, contact and non-contact recreation, shellfish harvesting, fish spawning, warm water habitat, and wildlife habitat. The Basin Plan also lists the following beneficial uses for Rodeo Creek: coldwater habitat, marine habitat, preservation of rare and endangered species, contact and non-contact recreation, fish spawning, and wildlife habitat.

As mentioned previously, in a memo to the San Francisco Bay RWQCB, SFAN suggested modifications to the RWQCB list of beneficial uses to more accurately reflect existing conditions and actual uses. The memo (see Appendix B) included modifications related to GOGA/MUWO, PORE, PRES, and JOMU water bodies. For GOGA, some of these changes include adding navigation as a beneficial use for Bolinas Lagoon. SFAN also recommended that Bolinas Lagoon tributaries and other small streams be individually named and identified for their beneficial uses. An additional change is that freshwater replenishment and shellfish harvesting do not apply to Redwood Creek. Groundwater recharge, fish migration, and preservation of rare and endangered species should be added as beneficial uses for this creek. For Rodeo Creek, marine habitat and contact recreation do not apply. These and other changes/additions are included in a table of beneficial uses in Appendix B.

There are seven beaches within the parklands. NPS Director's Order 83 states that "designated beaches are those that the Park identifies (using signs, brochures, etc.) as available to the public for contact recreation." Beaches include Stinson Beach, Muir Beach, Tennessee Beach, Rodeo Beach, Horseshoe Cove (Fort Baker), Ocean Beach and Aquatic Park. Stinson Beach is the only swimming beach where a lifeguard is present. Additional recreational areas, Baker Beach and Crissy Beach, are located within the boundaries of the Presidio (PRES).

There are several listed aquatic species within GOGA/MUWO watersheds. Federally threatened steelhead trout (*Oncorhynchus mykiss*) and coho salmon (*Oncorhynchus kisutch*) spawn in Redwood Creek (GOGA/MUWO); steelhead trout also spawn in Easkoot Creek. An annual steelhead trout migration also occurs in San Pedro Creek (GGNRA, 1999). This is notable since it is the only creek within 30 miles of San Francisco providing this type of habitat (San Pedro Creek Watershed Coalition, 2002). In addition to salmonids, there are other T & E species associated with GOGA/MUWO watersheds. These include the federally threatened California red-legged frog (*Rana aurora draytonii*) that is found in and along several ponds and streams in many areas of the park including the South Lands. The tidewater goby (*Eucyclogobius newberryi*) is a federally endangered species found in Rodeo Lagoon. The federally listed Sacramento River winter- run Chinook are found in San Francisco Bay but do not enter any GOGA streams. The San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*) and Steller Sea Lion (*Eumetopias jubatus*) are also found within GOGA watersheds (Golden Gate NRA, 1999).

Past Inventories/Monitoring

Water Quality & Flow Monitoring

Water quality monitoring efforts within GOGA (including MUWO) have been on going (though not continuous) since the late 1980's. Streamflow data exists from as early as the 1960's and 1970's, though in general flow data is lacking (i.e., it is far less copious than chemical and biological water quality data). Monitoring sites have been located in several different watersheds but recent monitoring has focused primarily on evaluating impacts associated with stable operations. Park personnel, USGS, local universities, local government agencies, educational groups, and consultants have conducted monitoring. A significant portion of the data is contained within a database; more recent data is in spreadsheet form. Several reports have been written that describe the results of these studies (see reference section).

Marin Headlands/Stinson Beach/Bolinas Lagoon Areas

Water quality monitoring has been conducted in Redwood Creek and tributaries (including Kent Creek, Camino del Canyon, Banducci tributary, Green Gulch, and Golden Gate Dairy Tributary) at numerous locations throughout the years. Several data sets exist for discrete (i.e., short-term, focused) monitoring projects. For example, monitoring by the NPS in the Redwood Creek watershed was conducted in 1986-1988, 1990-1991, and 1993-1996. Much of the water quality monitoring focus within the park has been on lower Redwood Creek due to concerns related to nutrient and bacteria inputs in this locale.   A continuous temperature logger is located at the Redwood Creek gauge (this logger is removed prior to the rainy season).

Short-term data sets also exist for Rodeo Creek and Tennessee Valley (1994-1996). Rodeo and Tennessee Valley were monitored along with Green Gulch between 1998-2001 as part of intensive sampling related to stable operations and other potential sources of bacteria and nutrients (as mentioned earlier). Parameters typically monitored included flow (though flow data has been sporadic), pH, temperature, dissolved oxygen, conductivity, BOD (Biological Oxygen Demand), salinity, TSS (Total Suspended Solids), fecal and total coliforms, nitrates, ammonia, phosphates, Total P, metals (emphasis on copper), MBAS (Methyl Blue Activated Substances) and chloride.   Not all parameters were monitored at all sites. Redwood Creek, Rodeo Creek, and Tennessee Creek data collected by NPS is included in STORET and is being analyzed through the WRD Baseline Water Quality Data Inventory and Analysis Reports as well as a report by UC Berkeley. These results are discussed further in the data summary section of this document.

Consultants, USGS, and other entities have also conducted monitoring. For example the Stinson Beach County Water Agency has monitored Easkoot, Fitzhenry, and Blackrock Creeks for fecal and total coliforms since 1973 and nitrate, nitrite, and ammonia since 1986. GOGA deploys a continuous temperature logger at the Easkoot Creek (installed in the spring and removed before the winter storms). Also, a consultant conducted limited monitoring in Oakwood Valley and Nyhan Creek (Coyote Creek/Richardson Bay watershed), Redwood Creek, Tennessee Valley, and Rodeo Creek as part of an overall stormwater monitoring project.

Flow monitoring has also been conducted by various entities including the NPS, USGS, local universities and consultants. Flow monitoring sites have typically corresponded with water quality monitoring sites and include the Redwood Creek watershed (including Camino del Canyon, Kent Creek, Banducci Tributary, and Green Gulch Creek) as well as Easkoot Creek, Rodeo Creek, and Tennessee Valley. The USGS also monitored sediment and streamflow in Audubon Canyon and Morses Creek (near Bolinas) between 1967 and 1969. UC Berkeley (Lehre, 1974) monitored lone Tree Creek (south of Stinson Beach) between 1972 and 1974. Stream gauges were installed by NPS at Redwood Creek (Hwy. 1 bridge) and Easkoot Creek.

Macroinvert monitoring was conducted in 2000-2001 in the Tennessee Valley and Rodeo Creek watersheds. Sampling was conducted in the Redwood Creek watershed, including Fern Creek in 1995 and 1997 using a modification of the CSBP (California Stream Bioassessment Protocol). Sample sites fell within fish index reaches established by Jerry Smith (San Jose State University). Macroinvertebrate monitoring (aquatic bioassessment) was conducted in 2004 on Easkoot, Fitzhenry, Blackrock, and Rodeo Creeks as well as McKinnan Gulch and Morses Gulch. Monitoring followed the California Stream Bioassessment Protocol which is described in detail in *Measuring the Health of California Streams and Rivers* (Harrington & Born, 2003).

South Lands (San Mateo County)

Until very recently (January 2004), no monitoring of surface water had been conducted by NPS in the southern GOGA lands. Some limited water quality monitoring had been conducted within the San Franciscquito Creek Watershed (West Union Creek is located within this watershed), but no monitoring has been conducted on NPS lands.   The San Francisquito Creek Watershed Council is actively involved in management and monitoring of this watershed. Through the Watershed Council, consultants have monitored the Bear Creek Watershed (including West Union Creek). However, no sites have been located within Phleger Estate or the adjacent County Park.
In addition to three water quality monitoring sample events in 2004, macroinvertebrates were also collected following the California Stream Bioassessment Protocol.

The EPA and the City of San Francisco Waste Water Treatment Plant conducted water quality monitoring (including several indicator bacteria) in San Pedro Creek. A local high school student has also tested the creek for temperature, pH, conductivity, transparency, and oxygen. The San Pedro Creek Watershed Coalition has submitted proposal to conduct DNA testing and optical brightener testing to determine the source of high indicator bacteria levels in the creek (San Pedro Creek Watershed Council, 2002).

Beaches & Saltwater Resources

NPS staff, in conjunction with the County of Marin, monitor four beaches (Stinson Beach, Muir Beach, Rodeo Beach, and Horseshoe Cove (Fort Baker). Beaches are monitored weekly from April through October. In addition, Stinson Beach is also monitored monthly from November through March. A local community group (Surfriders) has conducted monitoring at Stinson Beach and other beaches. NPS beach monitoring data from 2001 to 2003 is kept in the Maintenance Division files (raw data) at Fort Cronkhite (Marin Headlands). Recent data (2002-2003) is also kept in a spreadsheet developed by the County of Marin Environmental Health Services. The City and County of San Francisco (CCSF) has been monitoring Ocean Beach, China Beach, and Aquatic Park since 1986. Current information on beach water quality is available at: http://www.earth911.org/WaterQuality. Past data is available through CCSF. Baker Beach (part of the Presidio of San Francisco) is also monitored by CCSF. Baker Beach is discussed in the Presidio section of this document.

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Groundwater Monitoring

Groundwater monitoring is primarily associated with the former army lands. The Army and GOGA Environmental Contaminants Specialists and Civil Engineers have monitored contaminated sediments and groundwater. Other spring or well (i.e., drinking water sources) monitoring would be conducted by the Maintenance Division. Locations of historic springs have been digitized from geologic maps. The SFAN Long-term Water Quality Monitoring Plan will focus on surface water as this is a much greater need (particularly for the coastal parks).

Weather Monitoring

A tipping bucket rain gauge is located near the stream gauge at Easkoot Creek, in addition an anemometer and thermometer are operated at nearby Stinson Beach (primarily for beach and surf conditions). A rain gauge is located on Redwood Creek (Hwy.1 bridge) and a full weather station is located at the Muir Woods Ranger Station. A weather station has also intermittently been located at Fort Cronkhite near Rodeo Lagoon. A weather station is also located at Fort Baker. Work is in progress to convert raw data from some of these stations to digital data and to compile data into a network database. Network staff are also working to automate stations that are not continuously downloaded or have only raw (paper) data. Staff also plan to install weather stations in GOGA's San Mateo County lands.

Land Use and Water Quality Issues

Overall Park Issues

GOGA manages a large area but very few complete watershed areas. All of the lands have been highly managed and altered through agricultural and military uses. Due to the size and nature of the park (including high visitor use, the urban interface, and multitude of land uses) there are several water quality related issues. Accelerated erosion due to roads, trails, and other uses and developments threatens the sediment balance and ecological health of several watersheds. Grazing is no longer allowed on GOGA managed lands (Golden Gate NRA, 1999) but some of the impacts remain. Bacteria and nutrient inputs from equestrian operations, pet waste, agricultural operations and, potentially, sewer and septic systems can impact wildlife and public health as well as the overall ecological balance of water resources. High phosphorus, fecal coliform, and total suspended solids (TSS) levels have been observed in Redwood Creek. Channel alteration (including dams and culverts) impacts the ecological health of park watersheds. These primary issues occur to varying extents within multiple park watersheds.

Many park water quality issues are related to facilities and structures. A roads and trails inventory exists and many structures are documented in the Maintenance Division's facilities database (Maximo). However, the need for a more thorough and accurate inventory of park facilities and structures (including dams, culverts, and outfalls) was apparent during the water quality planning meeting.

Work is in progress to more thoroughly document facilities/roads & trails and other water quality threats. For example, a sediment budget study was conducted in the Redwood Creek watershed as well as a report of all sediment sources in the watershed. Trail maps are being updated and erosion surveys continue throughout the Marin Headlands. A dam inventory will be included in the WRD Baseline Water Quality Data Inventory and Analysis Report ("Horizon Report"). Culvert mapping has occurred in Rodeo Valley. In some areas, the County of Marin and CalTrans have mapped Redwood Creek outfalls. There is a database associated with these maps that would also have culvert information.

Marin Headlands/Stinson Beach/Bolinas Lagoon Areas

Water rights are of particular concern within Redwood Creek, Stinson Gulch, Easkoot Creek, and McKinnan Gulch as these are water sources for local communities. Water withdrawals and subsequent lower water levels cause a reduction in dissolved oxygen that hinders aquatic species. This is of particular concern to threatened salmonids and has been a source of tension in surrounding communities (most notably Muir Beach and Stinson Beach).

As a testament to high/toxic nutrient loads, algal blooms have occurred in Rodeo Lagoon. In addition to nutrient issues, Rodeo lagoon sediments may contain elevated amounts of copper from copper sulfate (algaecide) treatment. Plus, the lagoon also receives drainage from a former Nike Missile site (sediments are potentially contaminated though this has not been tested).

South Lands (San Mateo County)

San Francisquito Creek is listed on the Section 303d list as being impaired by sediment and diazinon. Concerns in West Union Creek, a San Francisquito Creek tributary within Phleger Estate include erosion and runoff from trails. Land slides and significant bank erosion have been observed. Since trails in Phleger Estate are frequented by equestrians another potential issue is runoff of bacteria and nutrients.

Issues in Milagra, Sanchez and Calera Creeks are mostly unknown due to the lack of water quality data. However, suspected issues in these urban creeks include fertilizer or pesticide runoff from lawns in residential areas and a golf course. In addition, pet waste, oil and chemical runoff from roads, and bacteria and nutrient inputs from leaky sewer pipes are also suspected concerns.

A TMDL for diazinon addresses all urban creeks in the San Francisco Bay Area. Diazinon is a broad-spectrum insecticide that is primarily used in homes and on lawns and gardens (it was banned from use on golf courses or for sod production). It is in a class of pesticides called organophosphates, chemicals that were developed and used as nerve gases during World War II. Nationwide, diazinon is the most frequently detected insecticide in the USGS NAWQA (National Ambient Water Quality Assessment) program. Diazinon is not currently used on park lands.

San Pedro Creek is listed as impaired by high coliform counts (Appendix A). However, it is listed as low TMDL priority and therefore, there is currently no TMDL project or implementation plan in place. Work is underway to differentiate coliform sources (i.e., human (sewer system) vs. animal (pet waste) sources (San Pedro Creek Watershed Coalition, 2002).

Beaches and Saltwater Resources

Muir Beach and Fort Baker (Horseshoe Cove) have exceeded the bacterial standards (Table 2) for contact recreation (REC 1). Suspected sources at Muir Beach include animal wastes from farming or equestrian operations, and faulty septic systems. Pet waste is also a suspected source and Maintenance Division personnel have removed large quantities from GOGA beaches. Dog fecal material is a major concern at Ocean Beach and a source of nearshore contamination (Golden Gate NRA, 1999).

Drege materials are currently dumped within 300 yards of Alcatraz Island (Golden Gate NRA, 1999). The Dredge Materials Management Office (DMMO) regulates materials disposed at the Alcatraz dredge disposal site. The DMMO is a joint program of the San Francisco Bay Conservation and Development Commission (BCDC), San Francisco Bay Regional Water Quality Control Board (RWQCB), State Lands Commission (SLC), The San

Francisco District U.S. Army Corps of Engineers (COE), and the U.S. Environmental Protection Agency. The dredge disposal site is a concern due to unknown sediment composition in the dredge spoils. Sludge contaminated with DDE (Dichlorodiphenyldichloroethylene) was dumped near Alcatraz in 1989. Dredge materials (contaminated or not) can significantly disrupt marine benthic flora and fauna and consequently intertidal resources (Wakeman, 1975).

San Francisco Bay is impaired by mercury and PCBs (among many other contaminants, see Appendix A). TMDL implementation plans for mercury and PCB's in San Francisco Bay are currently in place. Other threats to marine resources include oil spills, sewage, and radioactive waste (at the Gulf of the Farallones National Marine Sanctuary). These are a threat to waterfowl, shorebirds, and other marine and estuarine species

Groundwater

Groundwater issues are mostly associated with the former military lands (Fort Baker, Fort Barry, Fort Cronkhite, Fort Mason, and Fort Funston). Most focus in the army sites has been on sediment sampling. Lead, arsenic and other metals associated with Army landfills typically are more likely to be bound to sediments than in a free form in the water.

Priorities & Meeting Summary for GOGA

The largest need for these parks is data management and analysis. Then, based on the results of analyses, park staff can prioritize management issues. Despite the need for data analysis before issue prioritization, a few priorities were clear including:

1. Conduct an inventory of water resources in the GOGA South Lands.
2. Conduct data analysis and provide feedback to resource managers.
3. Obtain baseline data where needed.
4. Coordinate with park staff and forge relationships with local watershed groups.

Recommendations for Future Monitoring

Based on the results of data analysis, long-term monitoring stations (possibly including baseline sites plus sites applicable to large, long-term projects, stormwater monitoring, or other project specific/permitting needs) can be established. For the GOGA South Lands the initial focus will be on an inventory of the water resources and on collecting baseline data to determine potential pollution sources. In addition to the south lands (Milagra, Sanchez, Calera, and West Unions Creeks), baseline monitoring will be initiated on Nyhan Creek (in the Marin Headlands) and Oakwood Valley where only limited monitoring has been conducted. Baseline data is also lacking for several of the small coastal streams (many are tributaries to Bolinas Lagoon). Any monitoring activities on Redwood Creek will require coordination with existing project managers and other park staff. Coordination with the stormwater monitoring program may also be required.

During this planning meeting, many details were discussed along with the general state of water quality. Some of these details included suggestions for refining the monitoring program. These suggestions were primarily related to nutrient monitoring and were offerred by meeting participant Dr. Alex Horne (UC Berkeley). Since the freshwater systems in the parks are Nitrogen limited, phosphorus monitoring should be a low priority. Nitrogen should be monitored only where there have been problems (algal blooms). Existing data should be used to determine nutrient trends and background levels. Overall, there was general agreement that the emphasis for monitoring should be on surface water.

There is potential for coordination/partnerships with the San Francisquito Creek Watershed Council, Surfriders group (Stinson Beach), San Francisco Bay Keepers, Water Keepers, Mussel Watch, Tourist Club at Muir Woods and others. These are groups with potential monitoring involvement on or adjacent to park lands. More information needs to be sought regarding local watershed councils (e.g., check with the CA Department of Conservation). During development of the long-term water quality monitoring plan, consultation with Trails Forever, the Equestrian Plan, and other park management plans should also be conducted.

Pinnacles NM (PINN)

Pinnacles National Monument was established in 1908 by Proclamation No. 796 "to protect, for their scientific interest, the natural formations known as the Pinnacles Rocks" under Department of Agriculture Adminstration. At that time, the monument consisted of 2,060 acres within Pinnacles National Forest. The Pinnacles rocks are the remains of a 23 million-year-old Miocene volcano (Fesnock, 2002). Pinnacles NM was transferred to the Department of Interior in 1910 and became part of the National Park Service when the Service was created in 1916 Numerous boundary expansions have occurred since its establishment (NPS, 1980).

Located 35 miles south of Hollister in San Benito County, PINN now encompasses 24, 000 acres. It is southeast of Monterey Bay in the Gabilan Mountains. At 40 miles from the Pacific Ocean, it is the most inland park in the SFAN. PINN is surrounded by vineyards and cattle ranches. A private campground is located within the park.

Surface Hydrology & Water Resources

Ninety-five percent of the park is located within the Chalone Creek watershed but most of the Chalone headwaters are located outside NPS boundaries. The drainage area of Chalone Creek as it leaves the park is approximately 70 mi^2. The portion of Chalone Creek within PINN is braided and intermittent; it flows for approximately 5 months out of the year. The highest recorded discharge of 2,850 cfs was recorded in 1998, an El Niño-Southern Oscillation (ENSO) year. This was an estimated 40-50 year flood (Chad Moore, personal communication). Eventually this waterway drains into the Salinas River to the southwest of the monument.

Other drainages within the Chalone Creek watershed include the West Fork of Chalone Creek and Bear Gulch. These streams cut through the Pinnacles formations and played a role in the creation of the two sets of caves found in the monument (NPS, 1980). In addition, Sandy Creek drains from the east entrance of the park and flows along Hwy. 146. Other small tributaries include Grassy Canyon and Frog Canyon that meet Chalone Creek near the confluence of Chalone and Sandy Creeks.

Beneficial Uses and Aquatic Life

According to the Central Coast Regional Water Quality Control Board, Chalone Creek has the following beneficial uses: Agricultural supply, commercial and sport fishing, fish spawning, groundwater recharge, municipal supply, contact and non-contact recreation, wildlife habitat, and warm freshwater habitat. However, park staff indicate that many of these don't apply to the upstream sections of the creek within the park. It should be noted that beneficial uses are often designated due to past uses or potential uses of a water body. The Central Coast Regional Water Quality Control Board has not yet solicited comments regarding revision of their Basin Plan.

The Federally threatened California red-legged frog (*Rana aurora draytonii*) is present in some reaches within the watershed. Western Pond Turtles (*Clemmys marmorata*) (a species of special concern) are also present. The only known native fish are stickleback and they are abundant (Paul Johnson, personal communication).

Past Inventories/Monitoring

Water Quality & Flow Monitoring

PINN conducted water quality monitoring in the Chalone Creek watershed at 20 sites from 1997-2002. Monitored parameters included flow, dissolved oxygen, conductivity, salinity, temperature, color, pH, Total coliforms and E. coli, TKN, ammonia, organic N, nitrate, Total P, orthophosphorus, TDS (total dissolved solids), TSS (total suspended solids), and TOC (total organic carbon). Metals (gold, copper, lead, zinc, antimony, nickel, and barium) and general minerals were also analyzed. The samples have typically been collected during first flush (Dec/Jan.), peak flow (Feb/March), and baseflow (late May). Five key sites (of the 20 sites total) were monitored in February and May of 2004. PINN staff collected macroinvertebrates at six sites in PINN during 2004. USGS (Steve Fend) also surveyed aquatic worms in Chalone Creek (Paul Johnson, pers. comm).

One focus of the monitoring has been on areas downstream of a former landfill site located within the Chalone Creek floodplain. Benthic macroinvertebrates have been sampled in the South Wilderness area downstream of this landfill site. Nitrates and phosphate analyses as well as GMA (general mineral analyses) were also conducted in the creek downstream of the landfill site. Two peizometers were installed at the landfill site for water level monitoring. Water will be sampled in the future.

The WRD Baseline Water Quality Inventory and Analysis Report (NPS-WRD, unpub.) indicates that three separate data sets, all examining ground water quality, were found in STORET. Data included a Master's thesis (Donald Lee Brown) from 1961 measuring a suite of general minerals (silica (SiO_2), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), flouride (F), nitrate (NO_3), total dissolved solids (TDS), calcium carbonate ($CaCO_3$)), pH, and specific conductance) in the groundwater of Chalone Creek. Another study, by NPS (W.B. Reed) obtained PINN springs data from 1965 (Oak Tree Spring) and 1979 (Oak Tree Spring, Willow Spring, and Moses Spring). Data was obtained on lithology, flora, fauna, and discharge. Parameters monitored included temperature, SiO2, Ca, Mg, Na, K, HCO_3 (alkalinity), $CO_{3,}$ SO_4, chloride (Cl), flouride (F), nitrate (NO_3), Boron (B), TDS, $CaCO_3$, specific conductance, and pH. The USGS (J.P. Akers) also conducted a study to determine appropriate well locations. Three springs were monitored including Willow Spring, Split Rock Spring, and Oak Tree Spring. These were monitored in 1963 and 1967 for temperature, SiO2, Fe (Iron), Ca, Mg, Na, K, HCO_3 , $CO_{3,}$ SO_4, Cl, F, NO_3, B, TDS, $CaCO_3$, percent sodium (Na), specific conductance, and pH. Maps with site locations of these three studies will be included in the final WRD report.

<u>Weather Monitoring</u>
There are currently three NPS weather stations in operation at PINN. One station is centrally located near along a ridge behind park housing (above Chalone Creek and near park HQ). The other two stations are in the west side of the park. An air quality station is also located at PINN along Hwy. 146 across from Sandy Creek (east side of park). Data is download every two months.

Land Use and Water Quality Issues

Pinnacles NM shares some of the same water quality issues as SFAN parks; however, due to drier conditions, groundwater issues are a proportionally larger concern at PINN than the coastal parks. Reduction and contamination of groundwater and elevated levels of sediment, bacteria, and nutrients in surface waters have been identified by the park as current issues. Due primarily to past land uses, threats of heavy metal contamination are also a concern. Some of these concerns are not well documented; therefore, one goal of a long-term monitoring plan is to clearly identify threats to water quality in order to better understand the extent of contamination and address it.

Water withdrawal concerns stem from the parks' own water supply needs, surrounding vineyards, and possibly other unknown sources. The park's potable water tanks are flushed every two weeks for system sampling; water is discharged into the creek with unknown impacts on aquatic life (residual chlorine could be present though no impacts have been documented). Stream base flow in Chalone Creek is minimal but may be fed by an aquifer that drains from Bear Valley towards the southwest. This shallow aquifer is threatened by groundwater development within and outside the park and decreased groundwater levels have been observed (Chad Moore, personal communication). To illustrate, surface water appears to dry faster and larger amounts of water were present in streams in the past (e.g., accounts from the 1950's indicate the presence of beaver). Information from well logs and oral history accounts needs to be compiled in order to thoroughly address this concern.

Regarding sediment, nutrients, and bacteria, Sandy Creek is the main water body of concern. It receives pollutants from Hwy. 25 and a nearby campground. Horse stables and a potentially faulty septic system at the campground may be contributing pollutants (high levels of phosphates have been detected). The presence of summer algal blooms in Sandy Creek and Chalone Creek has indicated elevated levels of nutrients.

Heavy metals are a potential concern throughout many areas of the park. A landfill (circa 1930) that was removed in the 1980's by the State is located within the floodplain of Chalone Creek. The landfill may be a source of heavy metals as well as other potentially toxic compounds. Other potential sources of metal contamination include a shooting range and a copper mine located within the park's boundaries. A fungicide (methyl bromide) applied to vineyards outside the park may also be a concern. Bear Gulch Reservoir was treated with copper sulfate for several years; high concentrations of copper in the sediments may be present.

Priorities & Meeting Summary for PINN

Priorities and needs (i.e. what can the SFAN provide the park?) can be briefly summarized as follows:

1. Provide technical guidance.

2. Conduct data analysis.
3. Add an outreach component to monitoring efforts.

Several questions arose during the water quality planning meeting, mostly regarding analysis of past data. Feedback on the Sandy Creek data (and whether or not is should be a concern) is needed. If the data is cause for concern, the park needs information on tracking the sources of high phosphates and E. coli in the creek. The park also needs water quality results that are in a cohesive, understandable (analyzed) form so that they can begin discussions with the community (landowners, Resource Conservation Districts (RCD), etc.)

Outreach is a significant need (there is currently no park-community interaction regarding water quality). The San Benito County RCD may be able to play a role in water quality issues within and surrounding the park. Participation in "Snapshot Day" or other large-scale monitoring efforts may encourage park-community partnerships.

As with many of the parks, background (natural) ranges in parameters need to be determined for PINN. Technical support is needed to provide input on sampling strategies (the number of sampling stations, frequency of sampling, and parameters to sample). Like other small parks, PINN will need staff to conduct or assist with sampling efforts. Having staff available to sample during "first flush" and peak flow is a primary need.

Recommendations for Future Monitoring

The meeting sparked discussion about the purpose of water quality monitoring at the park. Staff indicated that basic monitoring to protect the natural resources was the priority, though it was uncertain whether basic monitoring could answer management questions. Intensive, project-oriented sampling was a lower priority. Another issue that arose was whether or not Clean Water Act goals were sufficient (i.e., does achieving the CWA goals equate to achieving ecological goals for the park?) Resource issues may dictate that park water quality standards be higher standards than the CWA standards. This is something to consider at all of the SFAN parks.

Several years of data is needed to look at trends. Overall, basic monitoring is needed throughout the Chalone Creek watershed; however, a few parameters were specifically mentioned for some of the sub-watersheds. A sediment sampling strategy needs to be developed for Sandy Creek. Chlorophyll a and secchi disk depth were suggested parameters for Bear Gulch Reservoir. Emphasis on monitoring around the landfill site should be on nitrates and metals. Based on discussions with park staff, the following sites were determined to be priority sites:

<u>Priority Monitoring Sites</u>
Flow monitoring sites:
Bear Gulch bridge at RM bldg. (Bridge #1)
Downstream of Chalone road Bridge (Bridge #2), across from fire wayside exhibit
Sandy Creek across from air quality station (no bridges) (#3)

Obtain weekly flows in the winter from bridges #1, 2, & 3. Measure flow before, during, and after storm events

Water Quality monitoring sites:
Bear Gulch Reservoir
Sandy Creek (baseflow)

Additional sites will be monitored if that is determined to be necessary and funding is available.

Point Reyes NS (PORE)

Point Reyes National Seashore, located in western Marin County, California, is approximately 40 miles northwest of San Francisco. The park was established in 1962 by Public Law 87-657 in order to "…save and preserve, for the purpose of public recreation, benefit and inspiration, a portion of the diminishing seashore of the United States..." The jurisdictional boundary of PORE encompasses approximately 71,046 acres of beaches, coastal cliffs and headlands, marine terraces, coastal uplands, and forests (Point Reyes National Seashore, 1999). Thirty-three thousand acres are designated wilderness. Pt. Reyes NS also manages 19,265 acres of GOGA land as well as 22,000 acres of estuarine and marine waters, extending ¼ mile offshore and including most of the waters of Tomales Bay (south of the mouth of Walker Creek). The marine boundary of PORE is adjacent to two National Marine Sanctuaries (Gulf of the Farallones and Cordell Banks NMS).

Through the park enabling legislation and the National Parks and Recreation Act of 1978 (PL 95-625), landowners within the established park lands may "retain for himself and his/her heirs and assigns, a right of use and occupancy for a definite term of not more than twenty-five years or a term ending in death whichever is later". Approximately 18,000 acres are retained as a "pastoral zone." Within this zone, seven dairies and 15 beef ranching operations manage more than 6,300 cattle. In addition, PORE manages an additional 10,500 acres of beef cattle ranch lands within GOGA.

Surface Hydrology & Water Resources

There are three major creeks within the Seashore plus several small coastal watersheds. Major creeks include Lagunitas Creek, Olema Creek, and Pine Gulch. All of these are located in the eastern portion of the park; Lagunitas Creek flows through GOGA lands managed by PORE. Lagunitas Creek, and one of its tributaries, Olema are within the Tomales Bay Watershed. Drainages in the southern portion of the park, including Pine Gulch, are part of the Bolinas Lagoon Watershed. All other drainages flow into the Pacific Ocean (directly or via Drakes Bay).

Tomales Bay Watershed

Tomales Bay itself has several tributaries flowing from parklands including from south to north: Fish Hatchery Creek, Redwood Creek, Dreamfarm Creek, 1st, 2nd, and 3rd Valley Creeks (in the town of Inverness), White Gulch (in the Tule Elk Reserve just south of Tomales Point) and several unnamed tributaries. These tributaries all flow into the west side of Tomales Bay. There is one NPS managed beach on Tomales Bay – Marshall Beach. Other beaches are located in Tomales Bay State Park and other non-NPS public areas along the Bay.

The 88 mi^2 Lagunitas Creek watershed is the largest watershed within SFAN. Its headwaters flow from the north slopes of Mount Tamalpais, the highest peak in Marin County (and second highest in the San Francisco Bay Area). Four lakes were formed by the damming of the creek including (from upstream to downstream) Lake Lagunitas, Bon Tempe Lake, Alpine Lake, and Kent Lake. The Marin Municipal Water District (MMWD) manages these reservoirs. After leaving Kent Lake, Lagunitas Creek then flows north along the valley east of Bolinas Ridge, through Samuel P. Taylor State Park, through GOGA land (Giacomini dairy) and out into Tomales Bay near the town of Point Reyes Station. Flows in Lagunitas Creek (for the period of record since 1974) range from 22,100 cfs in the floods of January 1982, to 0.01 cfs during the drought of 1977 (Freeman et al., 2003). Within NPS lands (PORE/GOGA), there are several tributaries to Lagunitas include Olema Creek, Bear Valley Creek, Haggerty Gulch, and Tomasini Creek. Bear Valley Creek flows past the Park headquarters in Bear Valley (near Olema) and along the popular trail starting at the Bear Valley Visitor's Center.

The Olema Creek watershed is approximately 14.5 mi^2. Flows in Olema Creek range from intermittent up to approximately 3,000 cfs. Olema Creek flows north along California Highway 1. It is located in Olema Valley along the San Andreas Fault Zone. Several tributaries flow into Olema including from south to north: Randall Gulch, John West Fork, Giacomini Gulch, Davis Boucher Creek, Quarry Gulch, and Vedanta Creek. All of these except

Davis Boucher and Vedanta Creek flow from Bolinas Ridge (from the east). The western tributaries have significantly different geology since they are on the opposite side of the fault.

Bolinas Lagoon Watershed

Pine Gulch Creek flows parallel to Olema Creek for approximately two miles. The San Andreas Fault separates the two creeks. Pine Gulch flows south into Bolinas Lagoon. Much of the downstream portion of the creek is located on private lands. Several tributaries flow into Pine Gulch including (from north to south) Cottingham Gulch, Cronin Gulch, Copper Mine Gulch, Lewis Gulch and Wilkins Gulch. South of Wilkins Gulch, parklands are managed by GOGA. McCormick Creek is the major tributary from the west. The range of flows in Pine Gulch Creek is similar to Olema Creek. The Pine Gulch drainage area is approximately 7.5 mi^2.

Pacific Ocean and Drakes Bay Watersheds

Following the coast from south (Bolinas) to north (Point Reyes Headlands), there are several streams and lakes. Arroyo Hondo is the southernmost named stream. Further along the coast are several lakes including Pelican Lake, Bass Lake and Crystal Lake. Alamere Creek flows between that set of lakes and Ocean Lake and Wildcat Lake. All of these drain into the Pacific. Further up the coast are Coast Creek, Santa Maria Creek, and Laguna Creek. Dams are located on both Muddy Hollow and Glenbrook Creek that drain into Estero de Limantour. All of these water bodies are located primarily in wilderness areas.

Additional Creeks are located in the pastoral land including Home Ranch Creek, Schooner Creek, and Creamery Creek draining into Drakes Estero. Towards the Pt. Reyes Headlands, other minor drainages flow directly into Drakes Bay from the ranch lands. Moving further north in the pastoral lands, there are two major drainages. These include Abbott's Lagoon (approximately 7 mi^2 drainage area) and Kehoe Lagoon (approximately 4 mi^2 drainage area). Both of these lagoons are periodically connected to the Pacific Ocean. Frequency and duration of tidal connection is not certain at this time (summer observations show no connection; tidal influence in the winter is probable at least during large storm events). Drake's Estero, Estero de Limantour and Abbott's Lagoon are significant estuarine resources.

Beaches and Other Recreational Areas

There are numerous beaches accessible to the public within the Seashore. These include (from south to north) Palomarin Beach, Limantour Beach, Drakes Beach, Point Reyes Beach North and South (known as the "Great Beach"), Kehoe Beach, and McClure's Beach. Marshall Beach, along Tomales Bay was mentioned previously. In addition to these beaches, sunbathers and swimmers also frequent some of the freshwater lakes. Bass Lake and Hagmaier Pond, (east of Hwy. 1) are the most popular.

Beneficial Uses and Aquatic Life

Beneficial uses (BU's) within PORE watersheds include: agricultural supply, cold freshwater habitat, fish migration, municipal and domestic water supply, preservation of rare and endangered species, contact water recreation, non-contact water recreation, shellfish harvesting, fish spawning, warm freshwater habitat, and wildlife habitat. Additional beneficial uses for the Pacific Ocean include commercial and sport fishing, industrial service supply, and marine habitat (Appendix B). Anadromous fisheries and mariculture are significant BU's within PORE watersheds. Tomales Bay and Drakes Estero are shellfish harvesting areas; Drake's Estero is the site of one of the largest mariculture operations on the California coast.

There are various levels of recreational contact (primarily due to varying surf conditions) at the numerous beaches within the park. Limantour Beach and Drakes Beach are the primary contact recreation areas (as well as Abbott's Lagoon and, to a lesser degree, Kehoe Lagoon). Drakes Estero is a popular kayaking area. The Great Beach, Kehoe Beach, and McClure's Beach are unprotected with unpredictable, dangerous surf; therefore, swimming is not encouraged.

Federally threatened Coho Salmon (*Oncorhynchus kisutch*) and Steelhead trout (*Oncorhynchus mykisss*) are found in Lagunitas Creek, Olema Creek, and Pine Gulch Creek. Other cold Freshwater Habitats within the park (small coastal watersheds) may potentially provide spawning habitat for these salmonids. Chinook salmon (*Oncorhynchus tshawytscha*) are also documented regularly in Lagunitas Creek. Federally threatened California red-legged frogs (*Rana aurora draytonii*) are found in several areas of the park; federally endangered California freshwater shrimp are found in Lagunitas Creek. In addition to these federally listed species, the State listed Tomales Roach (*Lavinia symmetricus* ssp. *(=Hesperoleucus symmetricus)*), a species of concern, is also found within Olema and Lagunitas Creeks.

Several marine areas along the Point Reyes coastline have been recognized for their biological significance and receive some protection under state designation. The Point Reyes Headlands Reserve, Estero de Limantour Reserve and Duxbury Reef Reserve (which is adjacent to the Seashore's southern boundary) are protected under Title 14 of the California Code of Regulation through the California Department of Fish and Game (CDFG). The California State Water Resources Control Board has designated four areas along the coast –Bird Rock, Point Reyes Headlands, Double Point and Duxbury Reef – as Areas of Special Biological Significance (ASBS).

Past Inventories/Monitoring

<u>Water Quality and Flow Monitoring</u>

According to the WRD Baseline Water Quality Data Inventory and Analysis Report , there were 141 STORET stations within the park managed boundary covering virtually all of the watersheds. There were no long-term stations within PORE boundaries. The cumulative date of record was 1901-1998 (with the majority of observations occuring after 1954). PORE staff collected a significant amount of data including multiple observations for multiple stations over several years. However, much of the data collection occurred after the WRD STORET retrieval date of 12/20/99. Also, some older data had not yet been entered into STORET. Therefore, the WRD report does not include PORE data that is summarized in PORE Water Quality Monitoring Report (Ketcham, 2001) or the UCB report *A Review of the Water Quality Monitoring Programs in the National Parks* (Stafford and Horne, 2004). Agencies conducting monitoring included the USGS (Roberto Anima and others), California Water Resources Control Board (CWRCB), and USEPA.

Water quality monitoring of Tomales Bay and Drakes Estero has been ongoing since the early 1990s by the State Department of Health Services. Monitoring in these water bodies is mandated by shellfish production requirements. The USGS has monitored flow in Lagunitas since 1974 (Freeman et al, 2003). In addition, the USGS has recently completed a three-year study in four watersheds (within GOGA and PORE) supporting coho salmon and steelhead trout. This study utilized NAWQA (National Ambient Water Quality Assessment) protocols for sediment and nutrient monitoring. The Seashore has cooperated with a number of state agencies and private researchers to facilitate water quality research and monitoring. The NPS Water Resources Division completed the Baseline Water Quality Data Inventory and Analysis Report ("Horizon Report") for this park. A more thorough review of past monitoring activities is included in this document (National Park Service, 2003).

Since 1999, the PORE Ambient Surface Water monitoring program (quarterly and storm-event monitoring) has monitored approximately 30 sites in five watersheds (Lagunitas Creek, Olema Creek, Pacific Ocean, Drakes Bay, and Drakes Estero). A report (Ketcham, 2001) was produced by the park outlining results from 2000-2001. Monitoring has focused on evaluating the impacts of agricultural operations (dairy cattle, beef cattle, and equestrian operations). Quarterly monitoring continues to be conducted in these watersheds, though a more streamlined set of sites is being proposed. Parameters monitored by NPS (through the ambient surface water program) include pH, temperature, dissolved oxygen, specific conductance, flow, salinity, TSS (Total Suspended Solids), turbidity, fecal and total coliforms, nitrates, ammonia and orthophosphorus. Orthophosphorus was rarely detected, so this was dropped from the list of analytes. In addition to flow monitoring on these creeks, there are several staff gauges (e.g., Kehoe Creek, Abbott's perennial stream, A Ranch perennial stream, Schooner Creek, Home Ranch Creek, and Laguna Creek). Continuous temperature monitoring is conducted in Olema Creek (mainstem, Quarry Gulch , John West Fork) and Pine Gulch (mainstem). Temperature loggers are installed annually during the spring and removed before the winter storms.

In addition to quarterly monitoring throughout the park, more frequent, focused monitoring is also being conducted. Due to the listing of Tomales Bay as being impaired by pathogens, six sites on Olema Creek have been chosen for monthly monitoring as part of the San Francisco Bay Regional Water Quality Control Board's *Tomales Bay Pathogen TMDL Program.* In addition to monthly monitoring, the sites have been monitored six consecutive weeks during the winter and six consecutive weeks during the summer. Monitoring for this program began in June 2003 and is on-going.

An additional monitoring project was initiated in April 2004 as a response to the goals outlined in the NOAA Fisheries Biological Opinion (National Marine Fisheries Service, 2003). This monitoring project includes monthly monitoring of bacteria, sediment, and flow at five key sites throughout the park (two tributaries to Olema Creek, one tributary to Lagunitas Creek, and two creeks in the Drakes Estero watershed.

Since Tomales Bay is also on the Section 303d list for sediment impairment, Olema Creek was chosen for a pilot study in sediment monitoring. In addition to the stream gauge and staff plate already in place on Olema Creek, additional components of a Turbidity Threshold Sampling (TTS) unit (Lewis and Eads, 2001) were installed. These include an automated sampler and a turbidity sensor. The sampler is triggered at various turbidity thresholds. Relationships among flow, SSC (suspended sediment concentration), stage, and turbidity can then be developed. Data analysis (in progress) will determine the utility of this TTS station for watersheds in other SFAN parks. The TTS station was fully operational in winter 2003-2004.

A study conducted through GOGA (Beutel, 1998) included sites on Pine Gulch. SFAN and PORE initiated limited monitoring in late 2003. This monitoring covers the same parameters as monitoring on Olema Creek and the pastoral watersheds. However, due to private ownership of a portion of the watershed, site access has been sporadic. A water level monitor, staff gauge, and rain gauge are located on Pine Gulch a few hundred yards upstream of the creek mouth. Flow monitoring has been conducted in conjunction with water quality monitoring and as part of the salmonid monitoring program.

Past and current recreational monitoring has included lagoons, ponds, beaches (mentioned previously), and a lake (total of 11 sites). Currently, three recreational areas are monitored in conjunction with the Marin County Environmental Health Services. These areas include Limantour Beach, Drakes Beach, and Marshall Beach. PORE will be monitoring Kehoe Lagoon and Abbott's lagoon as part of a separate monitoring project.

In 2001, aquatic bioassessment was conducted at six sites in the Olema Creek watershed and six sites in the Drakes Estero watershed. In 2004, bioassessment was be expanded to include Pine Gulch Creek, additional Olema Creek sites, and Lagunitas Creek. Network and park personnel completed benthic macroinvertebrate sampling in April 2004 following the California Stream Bioassessment Protocol (Harrington & Born, 2003). A consultant (taxonomist) will perform insect identification and data summarization.

Synoptic or short-term water quality monitoring has also been conducted for various park restoration and research projects. For example, a Long-Term Monitoring Program is being developed for the Giacomini Wetland Restoration Project (Parsons, 2003). Initial monitoring for this program was conducted monthly.

<u>Weather Monitoring</u>
In addition to the datalogging tipping bucket rain gauges at the Pine Gulch Creek and Olema Creek, there are also rain gauges at Pierce Point (near Tomales Point in the northernmost part of the Seashore) and at the Pacific Coast Science and Learning Center (off highway 1 in the south district near Hagmaier Pond). Full weather stations are located at the Bear Valley HQ (weather data since 1996) and Inverness Ridge (deployed in 2002). Weather stations located at the Point Reyes lighthouse and at the North District (AT&T/MCI site) are in various stages of repair. An air quality station operated by the California Environmental Protection Agency is also located at the North District Site. With the exception of the lighthouse, all data is digitized. A unique feature for visitors and park personnel alike is the newly installed "Weather Cam" at the Point Reyes lighthouse. Current conditions can be viewed at: http://www2.nature.nps.gov/air/WebCams/parks/porecam/porecam.htm.

Land Use and Water Quality Issues

<u>Overall Park Issues</u>

There are several water quality issues within the park. These issues relate back to the beneficial uses of fish migration and spawning, shellfish harvesting, and contact recreation. Sediment and pathogens are the most significant issues related to these BU's (nutrient levels have not been a concern in the past but newer data needs to be analyzed). Erosion due to unstable geology, cattle grazing, roads, culverts, and trails threatens the sediment balance and ecological health of several watersheds (most notably, Olema Creek). Excess sediment has detrimental effects on salmonids including clogging of gills, embedding of gravel beds used for spawning, and inability to locate food sources. Due primarily to the significant acreage of pastoral land within park boundaries, bacterial contamination is also a very serious (and prevalent) issue. Bacteria inputs are primarily from dairy and beef cattle operations, but pet waste (particularly at beaches), stable operations, and septic systems may also be contributing. More details on these issues and the watersheds that they impact are discussed below.

Sediment

Tomales Bay and Lagunitas Creek are impaired by sediment. Lagunitas Creek (and its tributary, Olema Creek) are the subject of several sediment monitoring studies. In addition to the aforementioned NPS Turbidity Threshold Sampling study on Olema Creek, PORE has recently completed two streambank stabilization projects along Olema Creek. The USGS is conducting a sediment study in the Tomales Bay watershed and has installed turbidity sensors (in conjunction with stream gauges) at sites along Lagunitas Creek and Walker Creek. Collaboration with the USGS is expected to continue in the future.

Pathogens

Although the levels of fecal coliforms in Olema Creek are a focal point because of the Pathogen TMDL Program for Tomales Bay, very high fecal coliform numbers occur in the small coastal watersheds where dairy and beef cattle operations are located (including park designated pastoral lands and the Giacomini property). Work is in progress to determine exact sources which may include runoff from pastures and lots, direct access of cattle to creeks, and faulty septic systems. Two key watersheds in the park are highlighted below.

The Kehoe Lagoon watershed (including North Kehoe and South Kehoe Creeks and tributaries) is a major concern for PORE. Bacterial numbers throughout the watershed (combining data from five sites) range from an average of 35,000 MPN/100mL during the dry season to 350,000 MPN/100mL (an order of magnitude greater) during the rainy season. Through the beach monitoring program (in conjunction with the County of Marin) Kehoe lagoon was posted several times in 2003 for exceeding contact recreation criteria for indicator bacteria (fecal coliforms, *E.coli*, and *Enterococcus*). Kehoe Beach itself (saltwater) has consistently met the standards. A dairy cattle barn expansion is anticipated within this watershed. Since more cows will be housed in the barn, their waste can be better managed. Water quality data before and after barn expansion will be compared to determine the efficacy of the barn as a management practice to improve water quality.

The Abbott's Lagoon watershed is also a concern. Again, combining data from throughout the watershed (3 sites) the average low (dry season) fecal coliform count is approximately 6,000 MPN/100mL. Winter rain season counts have exceeded 1.6 million MPN/100mL in one tributary and are commonly over 10,000 MPN/100 mL in other tributaries. A barn was built in the summer of 2003 to house cattle and better manage waste. Preliminary results from winter 2004 monitoring indicate a marked decrease in fecal coliforms at two of the three monitoring sites (compared to fecal coliform results in previous winters). The average for the three sites was 8,700 MPN/100mL. Although this number still exceeds standards for non-contact recreation, additional decreases are anticipated in the next several years.

Data from water quality monitoring has provided impetus to conduct field reconnaissance and additional sampling aimed at determining direct sources of pathogenic bacteria (e.g., livestock with direct access to streams). Trouble-shooting, problem solving, and BMP implementation plans are underway for septic systems and dairies. For example, fencing has been installed or repaired at locations throughout the park. Focused monitoring of Kehoe Creek and Abbott's Creek has been initiated in order to differentiate sources.

Priorities & Meeting Summary for PORE

To facilitate discussion, some priorities were presented to provide an opportunity for the group to comment on them. These priorities included 1) monitoring for land use impacts, 2) monitoring for the TMDL program, and 3) recreational monitoring for public health.

One meeting participant (Dave Lewis, UC Extension) suggested a few points to consider when evaluating these (and other) monitoring priorities. He noted that recreational monitoring needs to be continued but methods are still being defined. Also, TMDL monitoring is important, but we also need a long-term dataset. Funding for baseline monitoring is not "glamorous" and it is more difficult to obtain funding for, but it is extremely important. Solving problems requires a level of monitoring beyond baseline monitoring. Once five to ten years of data are obtained, there is often more leverage for receiving funding.

In addition to the priorities discussed above, other needs and priorities are summarized below.

1. Data analysis for problem solving (and refinement of monitoring methods) is a large need.
2. Monitoring for the NOAA Fisheries Programmatic Agreement/Biological Opinion (B.O.) for grazing.
3. Monitoring corrective actions is also a need.
4. Baseline testing for metals and antibiotics should be considered.
5. Participation in water quality monitoring activities above the park service level (i.e., involvement with local watershed groups) is large need.
6. Similar to GOGA, maps of outfalls, culverts, septic systems and other facilities are needed. (These maps would then be overlain on watershed maps).

Recommendations for Future Monitoring

The park will use the existing monitoring plan; future monitoring locations depend upon the need for source differentiation. Efforts will also be made to streamline the list of monitoring sites. High priority sites will be part of the network monitoring plan (e.g., TMDL monitoring in Olema Creek would be a network priority because it relates to a GPRA goal (reduction in impaired waters)). Monitoring efforts will be coordinated closely with the USGS, Tomales Bay Watershed Council (TBWC), Tomales Bay Shellfish Technical Advisory Committee (TBSTAC), the Tomales Bay Agricultural Group (TBAG), the Regional Water Quality Control Board (RWQCB), UC Davis Extension and other entities conducting monitoring in the watershed.

Sites included in the recreational monitoring program should also be reconsidered and discussed with the Marin County Environmental Health Services. Areas where more water contact occurs such as Abbott's lagoon should be added to the monitoring plan. Areas where the park does not encourage swimming (due to dangerous surf, currents or other conditions) could be eliminated from testing. For example, Kehoe Beach and McClure's Beach have been tested in the past and met the bacterial criteria for swimming; however, these are dangerous beaches where the park has posted warning signs.

Future monitoring for marine water quality should also be considered. The Seashore coordinates with many agencies and organizations including the National Marine Fisheries Service (NMFS), the U. S. Geological Survey (USGS), the Gulf of the Farallones National Marine Sanctuary (GFNMS), the Central California Coast Biosphere Reserve (CCCR) members, U.S. Fish and Wildlife Service (USFWS), the Audubon Society, California Department of Parks and Recreation, Point Reyes Bird Observatory (PRBO), Marine Mammal Center (MMC), and California Department of Fish and Game (CDFG). There may be opportunities for partnerships with many of these agencies regarding marine water quality and weather monitoring at PORE as well as GOGA.

<u>Presidio of San Francisco (PRES)</u>

In 1989 the Base Realignment and Closure Act designated the 1,480-acre Presidio of San Francisco for closure. The Army departed in 1994 and jurisdiction over the Presidio was transferred to the NPS. In 1996, Congress created the Presidio Trust to preserve and enhance the Presidio in partnership with the NPS. In 1998, the Presidio Trust assumed responsibility for the non-coastal areas of the Presidio including most of its historic structures (this is referred to as "Area B"). The Presidio Trust manages 80% of the Presidio. Land managed by the National Park Service is referred to as "Area A" and includes all of the coastal areas as well as a few inner portions of the Presidio.

Surface Hydrology & Water Resources

The Presidio is highly urbanized and has limited surface water resources. Lobos Creek, located in the southwest portion of the Presidio, is the only aboveground stream located within the city of San Francisco. It drains a 3 mi^2 area. It is the drinking water source for the Presidio and is partly diverted into the Presidio Water Treatment plant at Baker Beach (see cover photo). What is not diverted outfalls into the Pacific Ocean. Essentially "around the corner" (to the northeast) is Fort Point. Located at the northwestern tip of the Presidio, beneath the Golden Gate Bridge, it has no surface water resources other than some hillside seeps.

Mountain Lake is a natural lake that has been highly altered (cut-off by a highway). It is located in the southern portion of the Presidio and is adjacent to the Presidio Golf Course. The Mountain Lake Enhancement Project is on-going.

There are also two very small streams located within the Presidio. Tennessee Hollow (approximate drainage area 0.4 mi^2), fed by El Polin Spring, is mostly below ground with only a very small segment of remnant creek channel. Restoration planning is underway with one of the main objectives to "daylight" a portion of the creek. Currently, only 800 m of the creek channel is above ground. The other small creek, Dragonfly Creek (a.k.a., Fort Scott Creek) is an approximately 0.3 mi^2 drainage fed by a perennial spring. Restoration planning for this creek is underway.

Crissy Marsh is a tidal marsh restoration project along San Francisco Bay adjacent to Crissy Field (a former airfield). A monitoring plan for the marsh is being developed. In addition to natural water resources, there is currently a Recycled Water Program within the Presidio. Irrigation of the former Crissy Air Field with reclaimed water began in summer 2003. This adds further impetus to the need for monitoring receiving waters (Crissy Marsh and San Francisco Bay) since the effects of the reclaimed water on water quality are unknown.

Beneficial Uses and Aquatic Life

Since all of the watersheds within the Presidio are very small and most are below ground (in culverts), the beneficial uses are mostly urban and are not listed in the San Francisco Bay Regional Water Quality Control Board's Basin Plan. However, San Francisco Bay and the Pacific Ocean have numerous beneficial uses which have been eluded to in previous sections (see also Appendix B). As mentioned, Lobos Creek is the drinking water source for the Presidio. Crissy Marsh is a highly visible area located near the recreational area of Crissy Field. This area has high visitation by walkers, joggers, dog walkers, tourists, etc. Baker Beach, Crissy Beach, and Mountain Lake are recreational areas (Mountain Lake is non-contact recreation only and is not monitored for swimming use).

Past Inventories/Monitoring

<u>Water Quality and Flow Monitoring</u>
The Presidio golf course (adjacent to Mountain Lake) has been monitoring stormwater runoff from the golf course once a year during the "first flush" (first major runoff event). One sample is taken from a pipe draining into Mountain Lake. Samples have been collected since 1996. The golf course (directly or through a consultant) monitors pH, TDS (Total Dissolved Solids), nitrate, ammonia, sulfate, phosphate, and any pesticide applied in the previous twelve months (Christa Conforti, pers.comm). All information regarding monitoring is contained in the golf course IPM (Integrated Pest Management) plan. The Presidio Trust and the Army have conducted past remediation in Mountain Lake; NPS has this data.

A long-term data set (multiple observations for several water quality parameters) exists for several sites on Lobos Creek. Data was collected by NPS and USGS. Urban Watershed Project (UWP, a non-profit group), through a contract with the Presidio Trust, has been monitoring Lobos Creek . Six sites were monitored through UWP in 2001 with a focus on fecal coliform issues. Limited sampling was also conducted through the NPS Environmental Remediation Program. The City and County of San Francisco (CCSF) has also recently conducted monitoring in Lobos Creek. The *Lobos Creek Water Quality Investigation and Management Plan (2001)* was produced by UWP (through the Presidio Trust). Through a consultant, the Baker Beach Water Treatment Plant operates a stream gauge on Lobos Creek. SFAN is in the process of acquiring this data.

Aquatic bioassessment has been conducted through research projects in Dragon Fly Creek (Castellini, 1999). However, no water quality data has been collected. Dragon Fly creek was used as a reference creek for the Tennessee Hollow bioassessment (since water in this creek is cooler and better habitat). Baseline water quality monitoring was conducted in Tennessee Hollow. El Polin spring that flows into Tennessee Hollow was monitored for fecal coliforms by NPS. Data should be in STORET.

Beach monitoring has been conducted for over 20 years by CCSF. This includes Total coliforms, *E. coli*, and *Enterococcus.* Beaches are sampled at least weekly including Crissy Beach and Baker Beach (San Francisco Bay).

Monitoring is also currently being conducted in Crissy Marsh through a restoration project. Excavation of the marsh was completed and tidal connection was established in November 1999. Data collection with a submerged continuous recorder began in fall of 2001. Parameters include basic chemical parameters (dissolved oxygen, conductivity, temperature, and salinity) (Ward, 2003). The City and County of San Francisco (CCSF) also monitors bacterial concentrations in the Bay (San Francisco Bay) outside the marsh 3 times a week (Arlene Navarette, personal communication). They (CCSF) include a sampling point inside the marsh any time the tidal inlet closes. No elevated levels of coliforms have been observed. Benthic macroinvertebrates have also been monitored (Ward, 2003). Nutrient sampling for storm drain outfalls into the marsh will be added in the future. Monitoring through the stormwater management plan will assist with differentiating pollutant sources within the Presidio.

Other monitoring activities in the Presidio have centered around wells that have been monitored quarterly (or less often) by the well-established NPS Environmental Remediation Program. Well parameters monitored include dissolved metals, ions, VOCs (volatile organic compounds) and nitrates. They are monitoring in specific contamination areas; the wells are not intended to be long-term but cleaned-up and then closed. Presidio Trust has a database with all of the remediation information.

Weather Monitoring

A weather station is located atop the Crissy Field Center adjacent to Crissy Marsh. The Presidio Golf Course also operates a weather station. Information about accessing data from these stations (and subsequent data archiving) is forthcoming.

Land Use and Water Quality Issues

Water quality issues within the Presidio include pesticides/chemicals, landfills, hazardous waste, heavy metal contamination, nutrient inputs, public health (contact recreation) and sanitary sewers/storm drains. One of the main threats to Lobos Creek is leaky sewer pipes that cross the creek. There is also a landfill above the source of Lobos Creek. Ground disturbance and contamination are potential issues with this landfill (known as Landfill #10). Lobos Creek also has high bacteria numbers at the Baker Beach outfall. Warning signs have been posted at Baker Beach due to water samples exceeding the criteria for contact recreation. Most heavy metal contamination problems are prevalent throughout the Presidio; metals are mainly a concern for sediments. For Mountain Lake, nutrients and pesticides due to golf course runoff are a potential concern. However, there are historical concerns with heavy metals and other toxic contamination in this lake. Tennessee Hollow data results are unknown at this time, though fecal coliforms and nutrients are suspected issues.

Priorities & Meeting Summary for PRES

Discussions during this meeting were organized on a watershed by watershed basis. This was extremely helpful in determining priorities and needs.

Summary of Priorities & Needs

1. Assistance with coordination of stormwater monitoring is needed.
2. Monitoring of Crissy Air Field receiving waters (marsh) is needed.
3. Pre-restoration monitoring for Tennessee Hollow, Dragonfly Creek, and Mountain Lake are current needs.
4. The primary need is for development of a long-term surface water quality monitoring plan that includes Lobos Creek, Tennessee Hollow, Dragonfly Creek, and Mountain Lake (and potentially Crissy Marsh as well).
5. Technical assistance related to future monitoring and potential monitoring locations is needed.

There is currently no funding for stormwater monitoring. The Presidio Trust has a Draft Stormwater Management Plan. Guidance is needed on the following questions related to writing a Stormwater Management Plan:

- Do both NPS and Presidio write the plan? (Should NPS write a plan as well or work together with the Trust?)
- Who conducts the actual monitoring?
- Would the level of monitoring that the Trust wants to do differ from what NPS needs or wants to do?

- Will NPS review the Trust's draft?
- Are there any exemptions from any facets of storm water monitoring because it is a National Park (e.g., can BMPs (Best Management Practices) satisfy all or most of the requirements)?

Crissy Marsh monitoring will continue as part of the restoration project until 2005. At that time, funding is uncertain and SFAN may need to consider the needs of this project in the long-term monitoring plan. The marsh may be expanded in the future. The park also needs to determine what needs to be monitored (what contaminants would be of concern) in the Recycled/Reclaimed Water Program. Nutrients, Boron, pesticides and pharmaceuticals were suggested parameters to monitor.

For Tennessee Hollow, water quality monitoring is needed before, during, and after the restoration efforts. A specific monitoring question would be: Does water quality change from when the creek is free-flowing (daylighted) to when it goes into a pipe? If it were a positive change, then this would be good impetus for future stream restorations.

The primary need for Mountain Lake is monitoring for the Mountain Lake Enhancement Project that is set for completion between 2005-2008. Restoration and monitoring would be focused on ecological parameters rather than recreational/public use. The NPS goal for Mountain Lake is for non-contact recreational use and for a better function "natural" lake since it is natural but impacted and constricted by the road. The proposed uses of the lake determine the needs for water quality monitoring.

For Lobos Creek, the main need is long term monitoring upstream of the water treatment plant. Source differentiation may be needed. Research and implementation of corrective actions is also a foreseeable need.

Recommendations for Future Monitoring

Future monitoring needs were discussed above; though no specific monitoring locations were discussed. One facet to consider for the long-term monitoring plan is that there are two areas of the Presidio. Area "A" is NPS land including all of the coastal areas plus two smaller areas. Area "B", Presidio Trust land, is everything else. From a watershed standpoint, essentially all water flows from Area B to Area A and this is an important factor for management considerations. Development of the long-term water quality monitoring plan will be coordinated with both the Presidio Trust and the National Park Service.

SUMMARY OF WATER QUALITY PLANNING ("SCOPING") MEETINGS

Meeting Process and Functionality (Lessons Learned)

Every meeting was a "trial and error" because each park is organized differently and has a unique set of water resources, monitoring efforts, and water quality issues. Because of this, and lessons learned from each meeting, a slightly different set of discussion questions was used for each park (see Appendix E). Another option to consider for this type of information gathering is to use a questionnaire that would be sent out before the meeting (or possibly instead of a meeting). However, without a meeting, there is less opportunity for interaction and for forging relationships necessary for coordination of future monitoring efforts. The meeting was a good first step in introducing the I & M Long-Term Water Quality Monitoring Program and the monitoring plan development process.

Although PRES and MUWO are part of GOGA, PRES was separated out because of concern over the large extent of all three of those parks. Also, NPS and the Presidio Trust jointly manage the Presidio. However, it may be beneficial in the future to combine meetings for GOGA/MUWO and PRES because several of the same staff are involved with these parks. The use of a large set of specific questions (GOGA/MUWO) resulted in a discussion that was more detail oriented and less focused on "the big picture". With the Presidio meeting, a watershed focused discussion made priorities and needs more clear. A discussion that was watershed based may have been especially useful for these larger parks rather than an issue-based discussion.

In addition to a discussion organized by watershed, a streamlined set of discussion questions worked better (with broader issues and questions to urge discussion rather than a longer list of very specific questions). A list of discussion questions was not used for PINN (the first in the series of five planning meetings) and this would have been beneficial. For smaller parks (JOMU) in particular, discussion was especially useful for determining what threats to water quality existed, where monitoring stations might be located, and what the purpose of monitoring would be.

Overall, planning meetings suggested that a forum for discussion water quality issues was very useful and will be necessary in the future. The primary way to achieve this forum is to have an individual organize it and have regular meetings (e.g., annual or semi-annual). Regardless of the status of monitoring programs or on-going water resources projects, all parks had a great need for coordination and development of a long-term monitoring plan.

Overall SFAN Issues, Needs, & Questions

Primary SFAN issues include agricultural operations (dairy and beef cattle ranching, vegetable farming, viniculture, mariculture), recreational use (beaches, stable operations, dog walks), erosion and sedimentation, and water supply (flooding, overwithdrawal). Data analysis is a very large need for the network. Feedback on existing data is needed before management strategies can be prioritized. Parks should conduct short-term monitoring to meet legal requirements. Long-term, intrinsic monitoring should be threats based, biologically based, and provide a baseline. Sediment is a source of impairment for many of the impaired water bodies in SFAN and sediment problems are often facilities related. Therefore, a comprehensive facilities inventory should be a priority. This can assist staff with focusing on what *can* be changed within watersheds. Maps of wells, landfills, culverts, septic systems, stormwater outfalls, etc. and their location in relation to water bodies would also be helpful, if not essential, tools.

SFAN needs:

- A regular forum for discussing water quality issues,
- Coordination of monitoring efforts,
- Baseline water quality monitoring (including bioassessment),
- Outreach,
- Data analysis and feedback,
- A good database that can easily produce a report and provide spatial representation of all sites,
- Pollutant source differentiation,
- Facilities inventories,
- A list of water quality related references (ideally and annotated bibliography),
- A "data advocate" to ensure that data is sound and meets needs,
- A "data advocate" to work with regulators and other agencies,
- A way to meet the needs of the parks and the overall Vital Signs monitoring as well as relate to specific projects, and
- A flexible plan (adaptive monitoring) due to the uncertainty of future problems and needs

General Questions

1. Do we need to add or drop parameters to sample?
2. Should we reduce the number of sampling stations, or change the frequency of sampling?
3. How much data is need in order to have "baseline data"?
4. What watersheds have basin management plans?
5. What other monitoring plans exist? Are there monitoring plans that are part of watershed management plans?
6. What are our reporting requirements for water quality data?

Monitoring Questions

1. Are the data useful in guiding management decisions?

2. What is our level of compliance with beneficial uses?
3. What are the existing levels of X, Y, and Z? (Baseline data are needed.)
4. What are the natural ranges in values of X, Y, and Z? (Long-term data are needed.)

Water Resources Vital Signs Indicators

Meeting participants from the SFAN Vital Signs Workshop in March 2003 recommended the following potential indicators for monitoring water resources:

- Water Quality (core parameters: temperature, pH, dissolved oxygen, conductivity)
- Water Clarity (sediment and turbidity)
- Nutrients (Total N and Total P for marine systems baseline, ammonia for freshwater systems)
- Metals (baseline)
- Pathogenic Bacteria
- Benthic Macroinvertebrates
- Oil/Hydrocarbons
- HAB (Harmful Algal Blooms)
- Surface Water Dynamics (flow, discharge, use)
- Groundwater Dynamics (water table, recharge, drawdown, use)
- Oceanographic Physical Parameters (sea level, currents, upwelling)
- Flooding
- Waves
- Drought.

Table 7. Monitoring History of Selected Indicators

Indicator	Monitoring Purpose	Parks Monitoring*
Water Quality	Status & trends / Regulatory	GOGA, PINN, PORE
Water Clarity	Status & trends / Regulatory	GOGA, PORE, PINN
Nutrients	Status & trends / Regulatory	GOGA, PORE, PINN
Metals	Status /	GOGA, PINN
Pathogenic Bacteria	Status & trends / Regulatory	GOGA, PORE, PINN
Benthic Macroinvertebrates	Status	GOGA, PINN, PORE,JOMU
Oil/Hydrocarbons	Status & trends	
HAB	Status & trends	
Surface Water Dynamics	Status & trends	GOGA, PINN, PORE, JOMU
Groundwater Dynamics	Status & trends	PINN, PORE, GOGA
Oceanographic Physical Parameters	Status & trends	
Flooding	Status & trends	
Waves	Status & trends	
Drought	Status & trends	

* Includes past or present monitoring

Modifications to the original list of indicators/parameters resulted in broader indicators (Table 8). For example, water clarity, water quality, nutrients, and pathogenic bacteria were combined into the "Freshwater Quality" indicator. It is this indicator specifically, not the collective water resource indicators, that is the focus of the WRD Water Quality Monitoring Plan for the network.

Table 8. Water Resources Indicators

Former Water Resources Indicator from Vital Signs Scoping Workshop	New Indicator for Ranking
Water Quality	Freshwater Quality
Water Clarity	Freshwater Quality
Nutrients	Freshwater Quality
Metals	Freshwater Quality
Pathogenic Bacteria	Freshwater Quality
Benthic Macroinvertebrates	Aquatic Invertebrates
Oil/Hydrocarbons	Marine Water Quality
HAB (Harmful Algal Blooms)	Marine Water Quality
Surface Water Dynamics	Freshwater Dynamics
Groundwater Dynamics	Groundwater Dynamics
Oceanographic Physical Parameters	Physical Oceanography
Flooding	Resiliance Monitoring-Flood
Waves	Physical Oceanography
Drought	Catastrophic Event Documentation

The following water resources indicators were included in the SFAN ranked list of Vital Signs Indicators:

#1 Weather/Climate
#3 Freshwater Quality
#14 Freshwater Dynamics (Stream Hydrology)
#15 Wetlands
#16 Riparian Habitat
#20 Soil Erosion/Deposition
#31 Stream Channel and Watershed Characterization
#33 Marine Water Quality
#43 Groundwater dynamics
#62 Aquatic Invertebrates

Due to the presence of T&E species, Section 303d listed waters, significant coastal waters, unstable geomorphology, and public water use and health issues, network watersheds receive substantial attention from the surrounding communities and government agencies. The inclusion of the above Vital Signs indicators in the ranking list illustrates the significance of aquatic resources in the network. Several NPS efforts to improve water resources within SFAN are underway; continued and augmented monitoring is needed to ensure that existing linkages among these indicators, and the flora and fauna that they support, remain viable.

PRELMINARY SUMMARY OF SFAN WATER QUALITY DATA

Overview

Monitoring efforts within GOGA (including PRES and MUWO) have been on-going (though not continuous) since the late 1980's. Sites have been located in several different watersheds and monitoring has focused primarily on evaluating impacts associated with stable operations. PINN has conducted baseline water quality monitoring in Chalone Creek (at sites throughout the park) since 1997. PORE monitoring (since 1999) has focused on evaluating the impacts of agricultural operations (dairy cattle, beef cattle, and equestrian operations). Water quality monitoring of Tomales Bay and Drakes Estero has been ongoing since the early 1990s in conjunction with State Department of Health Services shellfish production requirements. In addition, the USGS has recently completed the last of a three-year NAQWA level water quality monitoring of four watersheds (within GOGA and PORE) supporting coho salmon and steelhead trout.

Pathogenic bacteria are a primary threat to water quality in SFAN. Indicator bacteria have consistently exceeded water quality criteria at many inland surface water monitoring sites at PORE and GOGA. This pollutant is also suspected to be a threat at JOMU and possibly PINN. Seasonal variability in bacteria concentrations has been detected and correlates with rainfall and runoff conditions. Efforts to improve water quality are on-going. A consultant for PORE has performed "Dairy Waste Management System Evaluations" for all of the ranches in the park. Best Management Practices have been implemented and research by local universities is proposed for the Tomales Bay watershed.

The following data review includes a summary of a report completed by UC Berkeley that analyzes data from PORE, PINN, and GOGA. Data summaries from the WRD Baseline Inventory and Analysis reports are also included. The WRD reports provide additional data, specifically past NPS data and data from other entities/agencies. Pertinent NPS information not included in either the UCB or WRD reports is also added. A thorough analysis of macroinvertebrate data is pending.

NPS-WRD Baseline Water Quality Inventory and Analysis Reports (Horizon Reports)

WRD Baseline Water Quality Inventory and Analysis Reports (a.k.a Horizon Reports after the consultant (Horizon Systems) that originally assisted with the project) were reviewed for EUON, JOMU, and PORE. Reports for GOGA and PINN will be completed soon. WRD has a comprehensive set of data queries that are used to summarize water quality data in an efficient manner. General station history and data for GOGA and PINN is included here but more detailed summaries will be added as they are completed. Thanks to Mike Matz and Dean Tucker (WRD) for providing some preliminary (unpublished) information from the GOGA Baseline Water Quality Data Inventory and Analysis Report. They provided the station spreadsheet and the Draft Executive Summary utilized here.

The Horizon reports include data from EPA's STORET database up to Jan. 1999 as well as other water resources-related databases. The GOGA data included in the UCB analysis is also in STORET. These reports include an Executive Summary that highlights monitoring stations that have exceeded EPA Water Quality Criteria for specific parameters. Station-by-station summaries, parameter summaries for stations, and annual and seasonal summaries (for stations with data meeting plotting criteria) are also presented.

The Study Area for the Horizon reports includes all waters within at least 3miles upstream and 1 mile downstream of park boundaries. However, only those stations within the NPS managed boundary were reviewed and are included in this summary. For a select number of sites (those meeting defined "plotting criteria"), seasonality was graphically displayed for nutrient and indicator bacteria parameters. At least for PORE, many monitoring stations had very few observations (were one-time sampling events) or had several observations over a one-year period. These sites did not meet the plotting criteria of multiple observations in each year and multiple years of observations.

UCB Report

SFAN aquatic professionals contracted with the University of California-Berkeley (UCB) to review and analyze data from GOGA, PINN, and PORE. Information from several SFAN reports was included in the data analysis. These data and reports include the following (full citations are in the reference section):

i. "1996 Fall Fish Kill Evaluation for Rodeo Lagoon, Golden Gate National Recreation Area, Marin Co." (Fong, 1996)

ii. "Winter 1997-1998 Water Quality Monitoring at Golden Gate Dairy Tributary" (Fong and Canevero, 1998)

iii. "Golden Gate National Recreation Area Storm Water Monitoring Program 1997/1998" (Beutel, 1998)

iv.

v. "Winter 1999-2000 Water Quality Monitoring at Golden Gate National Recreation Area Stables"

vi. "Winter 2000-2001 Water Quality Monitoring at Golden Gate National Recreation Area Stables"

vii. "Point Reyes National Seashore Water Quality Monitoring Report, May 1999 – May 2001." (Ketcham, 2001)

The UCB report ("A Review of the Water Quality Monitoring Programs in the National Parks in Central Coastal California" by Stafford & Horne, 2004) includes a comprehensive discussion on each water quality parameter currently or historically monitored by the three parks. The report addresses the importance of monitoring each parameter, influences on the parameters, the relation of the parameters to overall water quality, typical values and ranges, and history and status of monitoring within SFAN. It also provides a monitoring critique and recommendations for future monitoring. In addition, the report addresses many of the primary questions in WRD guidance (Irwin, 2004). It discusses typical levels and criteria limits for monitored parameters as well as seasonal and diel variability. This knowledge of natural ranges, variability, and water quality limits is critical to understanding aquatic systems and developing a long-term monitoring plan.

The data summary below discusses all data for each park (GOGA (including MUWO), PINN, PORE) where data exists. Data from multiple sites was combined and analyzed on a temporal scale in order to gain an overall idea of natural ranges and variability. Monthly averages for all data (all sites, all years) are represented graphically in the report. The intent was to provide a broad overview of average values and natural ranges in variability across watersheds (i.e., at a parkwide level rather than a watershed level). For the full data review refer to the complete UCB report in Appendix G.

Water Quality Criteria and Natural Ranges and Variability in Water Quality Indicators

According to the WRD Baseline Water Quality Data Inventory and Analysis Reports reports reviewed thus far, there was not sufficient data on core parameters (pH, conductivity, dissolved oxygen) to determine annual or seasonal trends for a particular station within PORE. Measurements of pH were noticably lacking in past station data (PORE horizon report). However, no station observations within PORE managed lands exceeded the EPA criteria (for pH or D.O).

<u>Flow (Qualitative Summary)</u>
Flow varies widely with seasonal rainfall. Data is available on mean flows for each of five gauging stations within the network as well as longer-term water quality monitoring sites. Data for specific streams (e.g., Olema Creek and Pine Gulch at PORE and Redwood Creek at GOGA) is available in *a Hydrologic Monitoring Station Information Summary* (Ketcham, 1998).

Flows for PORE (1997-2001) and GOGA (pre-1990 to 2001) are similar since both parks have very small, coastal watersheds with similar land use) while PINN (1997-2001) has a very different climate and watershed. Flow values include wadeable flow measurements or flow estimates taken in conjunction with water quality sampling. Currently, the goal of the SFAN is to develop rating curves for all streams with automated gauges. In general, for GOGA, mean flows are highest in January and February and lowest in June through September. For PORE, mean flows are highest in February, followed by January and March. The lowest mean flows occur in July. Highest flows at PINN occur in March (about a month after PORE/GOGA). At PINN, lowest mean flows (or more likely, immeasureable flows) have occurred June through November.

For the same amount of base flow in a stream in June through October, the measured flow is less in June and July since plants are transpiring at higher rates. Plant transpiration is highest during the day and lowest at night, so one would expect slightly higher flows at night. In addition to normal low flows during the summer and fall, drawdowns from surrounding wells can dramatically impact flows.

<u>Temperature</u>

> The temperature of the water is affected by several factors including the air temperature, humidity, percent shading, the turbidity or cloudiness of the water, as well as the temperature of groundwater and storm water inflows (Essig, 1998; Theurer et al., 1984). The flow is also important, since it takes longer for a larger volume of water to heat up, and water temperature is very sensitive to changes in air temperature when stream flow is low (Essig, 1998). In coastal California, the most important factor in small streams and rivers is the degree of shading provided by the trees and bushes of the riparian zone.
>
> In small streams, the temperature can vary as much as 10^{o} C over the diel (24 hour) cycle and a similar amount between shady and sunlit reaches (Bilby, 1984). Temperatures in smaller streams fluctuate more

than temperatures in larger streams and lakes. In bigger streams cooler temperatures are often found where groundwater enters the stream and at the tail end of gravel banks. In large pools and lakes, however, there can be considerable variation with depth, requiring several measurements to obtain a depth profile, especially in the summer when stratification is likely to occur. In larger rivers, coastal bays and estuaries, the temperature varies less, about 3°C per day, but is generally higher than in shaded streams since full sunlight reaches the water.

The San Francisco Bay Water Quality Control Plan states that "The natural receiving water temperature of inland surface waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Board that such alteration in temperature does not adversely affect beneficial uses," and that " the temperature of any cold or warm freshwater habitat shall not be increased by more the 2.8 °C above natural receiving water temperatures," (Lee and Taylor, 1995). Desired temperatures for streams depend on the stream type and location. For GOGA and PORE (parks with cold-water habitat), measured temperatures should be compared to the temperature preferences of threatened salmonid species.

The optimal thermal tolerance range for Coho salmon is from 11.4 to 16.6°C (Coutant, 1977). Steelhead trout prefer slightly cooler temperatures, from 10 to13°C (Bjornn and Reiser, 1991). However, salmonids and other fish can survive above their tolerance range if the exposure is brief or if the temperature increase is slow (days). Most salmonids can also survive much lower temperatures than their normal range but growth is slow and long-term population success is adversely affected. For example, for Coho the best growth is 11.8-14.6°C, which is also a good temperature for migrations upstream (Brett, 1952; Reiser and Bjornn, 1979). In contrast, lower temperatures, from 4.4 to 9.4°C are best for spawning and the early life stages of the fry (Brett, 1952; Reiser and Bjornn, 1979).

Temperature at GOGA and PORE has been consistently measured in the field with hand-held YSI meters. The median value for temperature in GOGA streams is 12 °C with an interquartile range (IQR) from 10.4 to 14.8 °C (Figure 4). In PORE, the median value is 11.9 °C with an IQR from 10.3 to 14.2 °C. The National Park Service Coho and Steelhead Restoration Project (CSRP) is conducting additional long-term temperature monitoring with data loggers to characterize the diurnal variations and thermal range of streams that are critical to the protection of coho salmon and steelhead trout (Ketcham, 2001). Temperature in PINN streams has been monitored starting in 1998 with a median value of 12 °C and an IQR from 10.9 to13.6 °C.

from A Review of the Water Quality Monitoring Programs in the National Parks in Central Coastal California (Stafford & Horne, 2004)

GOGA and PORE also have continuous temperature loggers installed in the late spring and removed before the first major storms in the fall/winter (see above sections on park background for additional information). This monitoring was initiated as part of the CSRP; data analysis is pending.

<u>pH</u>

Observations of pH between 1974 and 1997 were less than or equal to 6.5 in Lobos Creek and Rodeo Creek. The highest pH observed (10.8) was in Camino del Canyon in MUWO in Dec. 1997 (NPS-WRD report for GOGA, unpub.)

In distilled water, small amounts of acid or alkali will cause very large changes in pH. If chemicals such as calcium are present in water, the acid or alkali will interact with the calcium, which acts as a buffer to reduce swings in pH (Hem, 1985). In the California Coast Range streams, the sedimentary rock provides ample calcium and alkalinity. In a well-buffered system with good alkalinity, such as is found in these parks, there shouldn't be much change in pH. In general, pH will go down as a result of acid-rain deposition or high levels of respiration in the water column. On rare occasions, pH may be artificially elevated due to construction and road run-off. River water in areas not influenced by pollution generally has a pH in the range of 6.5 to 8.5 (Hem, 1985). Typical pH levels in the coastal central California region are in the range of 6 to 9 (Horne, Personal Communication), and the San Francisco Bay RWQCB water quality objective for pH is between 6.5 and 8.5 (Lee and Taylor, 1995). The range is the same for the Central Coast RWQCB; however, specific pH ranges vary slightly depending upon the beneficial use (e.g, the pH range for contact-recreation is 6.5 – 8.3). In the ocean, pH is always slightly alkaline (~7.5) but is so well buffered that it changes little under normal conditions.

If algae are abundant, large diurnal fluctuations in pH and DO may occur due to algal photosynthesis and respiration. High levels of respiration will increase the concentration of dissolved carbon dioxide, which forms carbonic acid and decreases the acidity (Hem, 1985). Acidity of water is an important parameter but changes over time in Coastal California are usually small since they are well buffered by calcium in the soils and water. In contrast, high levels of photosynthesis remove carbon dioxide and release alkaline ions raising the pH. Temperature has a strong effect on hydrogen ion activity and must be taken into account when determining and recording pH measurements.

At GGNRA and PRNS pH has been measured in the field with Waterproof Oakton pH meters with a detection limit of 0.1 pH units. They are calibrated regularly (Ketcham, 2001). The median value in GGNRA is 7.4 with an IQR from 7.0 to 7.8, which is comfortably within the desired range. There have, however been values as extreme as 6 and 10.8. In the PNRS, the median value is 8.0 with an IQR from 7.7 to 8.3. However, the top 10% of values are above 9.0, which is excessively high. It has been suggested that some of these measurements may have been taken soon after completion of road or path work using concrete. However, unless such observations are documented at the time the measurement is made, we have no way to know if this is the case, or if something else was causing excessively high pH or if the probe was simply malfunctioning. Without a documented reason, it is not valid to exclude these values as outliers (Zar, 1999). At PINN, pH has been monitored since 1997 with a median value of 7.9 and IQR of 7.7 to 8.2. However, the upper 10% of values are above 8.5, which exceeds the RWQCB objectives. Values of pH greater than 9.5 are likely errors due to malfunctioning of the pH meter or probe or to calibration problems. Such errors are quite common with field pH meters, which are sensitive to various disturbances. The field measurements of pH at PINN are consistently higher than the lab measurements of pH. This may be due to an actual change in the pH from the field to the lab, or it may be that the pH meter needs to be calibrated.

Conductivity/Specific Conductance

In rivers, the conductivity is mainly affected by the geology of the area through which the water flows (Behar et al., 1996; Creek Connections, 2004c; Hem, 1985). Near the ocean, it is influenced by saltwater intrusion and tidal fluxes, making it a less useful parameter for detecting pollution. In general, groundwater usually has higher conductivity than pristine surface flows, since it spends more time in contact with soil particles (Creek Connections, 2004c). As a result, perennial streams with groundwater sources may have higher conductivity during low flow periods when most or all of the water comes from groundwater then during high flow periods when most of the water comes from surface runoff. However, if the surface runoff has high concentrations of TDS due to erosion or high nutrient loadings, and base flows come from a reservoir rather than groundwater, the opposite pattern could be seen, with elevated conductivity during high flow periods.

As a measure of TDS and salinity, dramatic changes in conductivity are indicative of changes in concentrations of TDS which can include nitrate, phosphate and metals as well as sodium. High conductivity warns of problems in freshwaters and gives an idea of the water quality in coastal bays and estuaries. Generally, a high or increased conductivity in a freshwater stream indicates pollution upstream. For example, any inflow from sewage (treated or raw) will contain chloride ions since almost all human food is salted with NaCl (table salt) (Behar et al., 1996). Runoff from highways is often slightly saline and soil disturbances from construction release other ions that increase conductivity. Since conductivity is a very sensitive measurement, it can show unexpected or hidden pollution in freshwater systems.

Conductivity is very highly correlated with discharge (Hem, 1985), so analysis of specific conductance must include consideration of discharge measurements. The relationship between conductivity and discharge is not, however, always linear. In general, as discharge increases, solutes are diluted by the greater volume of water, and conductivity decreases. On a shorter temporal scale, the opposite pattern is observed in many streams, although closely studied in only a few places. There is a tendency for the water of a rising stage to have a considerably higher dissolved-solids concentration than the water passing the sampling point at an equal flow rate after the peak discharge has passed (Hem, 1985). The factors that control the concentration of water early in a flood event are different for different streams and sampling points. In general, however, when a sudden large inflow of water occurs upstream from a sampling point, the flood wave moving down the channel tends to push water already in the channel ahead of it. If the stream had a low or moderate flow rate before the rise began, the water in the channel would be relatively high in TDS, and as the wave moved downstream a large volume of this more highly mineralized water might accumulate in the wave front, resulting in higher conductivity than would be predicted by the flow rate (Hem, 1985).

Distilled water has a conductivity in the range of 0.5 to 3 uS/cm and the conductivity of rivers generally ranges between 50 to 1500 uS/cm (Behar et al., 1996). Seawater has a specific conductivity on the order of 50,000 uS/cm or 35 PSU (Hem, 1985). The average concentration of TDS for the world's rivers is 100 mg/L, while North American rivers average 143 mg/L (Creek Connections, 2004c). Most inland streams supporting good mixed fisheries have a range of 150 to 500 uS/cm and industrial water can range as high as 10,000 uS/cm (Behar et al., 1996). However, ecosystems are adjusted to local conditions, and a large change in TDS concentrations may disrupt the system and increase its overall sensitivity (Creek Connections, 2004c). At about 1700 uS/cm, the salt levels become lethal to freshwater fish (Ketcham, 2001). Most streams measured within Point Reyes and Golden Gate are within the range of 20 to 400 uS/cm, with a few on the order of 600 to 8000 uS/cm where seawater tidal influence or high pollution exists. The PRNS 2001 report concludes that sample sites with simple mean conductivity above 850uS/cm are considered impacted by land use activity (Ketcham, 2001). In addition, sites with conductivity between 500 and 850uS/cm were concluded to be likely impacted by existing land use activity (Ketcham, 2001).

Specific conductance has been measured at GGNRA, PRNS and PINN in the field with the hand-held YSI-30 and YSI-85 meters. In the GGNRA, the median specific conductance measured from 1997 to 2002 is 214 uS/cm with an IQR from 150 t0 600 uS/cm. In the PNRS, it is 314 uS/cm with an IQR from 203 to 663 uS/cm. At PINN, the median specific conductance measured from 1997 to 2001 is 285 uS/cm with an IQR from 192 to 491 uS/cm.

Turbidity/Total Suspended Solids

Peak turbidity and TSS are common during floods. Some TSS can also come from algal and bacterial growth. As the water travels downstream, solids are deposited in the streambed as water slows down in low energy areas. In California coastal streams, muddy water with high TSS is common in winter during high water flow. This is a natural result of the dry climate and occasional storms. The dry climate leaves large areas of the watershed covered only by dry grass that provides little protection from rain. Aquatic life is adapted to a certain level of TSS in the winter, Therefore, the interpretation of high TSS or turbidity as pollution or as a natural event depends on the circumstances. In terms of conventional pollution, many contaminants, such as phosphorous, metals and pesticides are attached to particles and travel with them. Increased levels of TSS often also means increased levels of any particle-associated contaminants in depositional areas

According to the 1995 RWQCB Basin Plan "Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses" (Lee and Taylor, 1995) Visible turbidity is found at greater than 5 NTU (Strausberg, 1983; Wilde and Gibs, 1998). The 2001 PRNS report recommends that over 50mg/L of TSS or 100 NTUs is cause for concern (Ketcham, 2001). A level of 40 mg/L TSS is about the level for concern unless the flow is storm water (Horne, 2003). For most fisheries, a level of > 300-400 mg/L TSS would actually clog fish gills and would also cover gravel beds where they spawn although some salmon swim through much higher TSS from glacial flour in Arctic rivers (Horne, 2003). The UC Cooperative Extension Fact Sheet on Fishery Habitat (Larsen, 1999a; Lloyd, 1987) provides a summary of the effects of varying turbidity and TSS concentrations on salmonids.

In the GGNRA stables study, grab samples were collected at every sampling event in sealed Whirlpaks and stored on ice in the field. Samples were transferred to a refrigerator and analyzed with 7 days of collection by NPS personnel in accordance with Standard Methods (APHA 1985). At PINN, TSS has been measured since from 1997 to 2001, not including 1999. The median value is below the detection limit of 5mg/l. The upper IQR is 22mg/L and instances of excursions up to 425 mg/L have been recorded. At PRNS, TSS has been monitored since 1997, with a median value of 17 mg/L, and an IQR from 6 to 86 mg/L.

High turbidity was detected in Olema Creek (but there was only one measurement). A turbidity of 80 NTU was measured; this exceeded the WRD screening criteria of 50 NTU (WRD Horizon report).

Oxygen Related Parameters

Sources of oxygen are from the atmosphere and algal photosynthesis (Hem, 1985; Larsen, 1999b). Oxygen in the water is depleted by respiration of fish, algae, bacteria and other organisms. Oxygen is also used in the process of oxidizing many wastes, including ammonia and organic matter (Rittman and McCarty, 2001). Flux of oxygen from air to water is generally low, so in stratified lakes a layer of oxygen-depleted water may form on the bottom while the surface water maintains higher DO (dissolved oxygen) levels (Horne and Goldman, 1994). An exception is well-mixed and turbulent streams with waterfalls and riffles where oxygen is rapidly introduced to the water. In such regions, oxygen depletion is rare. In contrast, in many normal streams the oxygen demand from falling leaves in autumn can depress DO even in the absence of human or agricultural pollution.

DO is a concern in the summer and fall as temperature rises, water flow drops, and leaf fall adds oxygen demand. Oxygen demand is measured as BOD (Biological Oxygen Demand in mg/L of DO) and all organic matter (e.g., urea, leaves, dead fish) has a measurable BOD. As temperature rises, the water is able to hold less DO (Weiss, 1970). Solubility of oxygen in water is also affected by the partial pressure of oxygen in the air and the dissolved –solids concentration in the water (Hem, 1985; Radtke et al., 1998b). Reduced flow generally means reduced turbulence and mixing, which limits flux of DO into the water.

As leaves fall in late summer and early fall, they are coated by a microbial biofilm of bacteria and fungi that feed on the cellulose and lignins in the dead leaves. As the microbes feed, they use up large amounts of oxygen. Since the leaf biofilm is the major source of food for stream insects and thus fish, the leaf BOD and potential lower DO is a normal part of a stream's seasonal cycle. Additional BOD from animal wastes or eutrophication, however, is not normal. In addition, microbial consumption of BOD can be more rapid at warmer temperatures.

RWQCB criteria levels for DO in inland (fresh) waters are set at 7.0 mg/L or above for cold water habitat and 5.0 mg/L or above for warm water habitat (Lee and Taylor, 1995). Estuaries can naturally have DO levels below 5 mg/L and no standard has been set by the USEPA or the San Francisco Bay RWQCB. However, such estuarine standards are under consideration at this time (2003) by the USEPA (EPA, 2001b). A level of > 3 mg/L seems to be a possible minimum for estuaries in California (Horne, 1998).

Generally, 0-2 mg/L or below 30% saturation is not enough DO to support aerobic life and is indicative of serious problems (Behar et al., 1996; Horne and Goldman, 1994). Almost all fish kills in natural waters (i.e. outside laboratory tests) are associated with DO < 2 mg/L (Horne, 2003). Such conditions can be expected in eutrophic pools where algae abound in warm still water or where excessive bacterial decomposition consumes the DO. With 2-4 mg/L of DO a few kinds of fish and insects can survive, but the water is still only 20-60% saturated and this low level is usually associated with warm, still water and/or high nutrients and bacterial growth. Most fish are affected by a lack of oxygen when DO is less than 4 mg/L (Larsen, 1999b; Reiser and Bjornn, 1979). With 4-7 mg/L of DO, the water is good for many pond animals, acceptable for warm water fisheries, but still too low for cold water fisheries. Salmonids show signs of initial distress symptoms at 6 mg/L of DO (Larsen, 1999b; Reiser and Bjornn, 1979). Below 60% saturation is still considered poor water quality, from 60-79% is acceptable for most stream animals, and above 80% is very good for most fish (Behar et al., 1996). For good cold water habitat supporting freshwater salmonids, over 7 mg/L of DO is needed (Larsen, 1999b; Reiser and Bjornn, 1979). It is important to note that with ample DO, fish can live through many other environmental threats, from ammonia to high TSS, which would otherwise kill them (Horne and Goldman, 1994). So maintaining a high DO can protect a fishery in many ways.

At PRNS, DO has been monitored in streams with the YSI-55 and YSI-85 since 1997, with a median value of 9.6 mg/L and an IQR from 8.1 to 10.5 mg/L. Ten percent (10%) of measurements were below 5 mg/L. The monitoring program at PRNS reports that low DO has been observed in association with isolated pools due to low flow, and that salmonids have been observed surviving in isolated pools with DO levels below 3

mg/L (Ketcham, 2001). At GGNRA, DO was first monitored in 1978 and has been consistently monitored since 1983, with a median value of 10.4 and an IQR from 9.7 to 11.0 mg/L. At PINN, DO has been monitored since 1998 with a median of 9.8 mg/L and an IQR from 9.3 to 10.5 mg/L. Ten percent (10%) of measurements were below 7.5 mg/L, mostly in cases where flow had stopped.

Typical raw sewage in urban areas usually has a BOD (biological oxygen demand) on the order of 250 mg/L. In rural areas, it is on the order of 80 mg/L. In a typical unpolluted stream, one wouldn't expect to find more than two mg/L of BOD. A stream with over 7 mg/L of BOD is likely to be negatively impacted (Horne, Personal Communication). The average DOC for rivers worldwide is 5.75 mg/L (Hem, 1985; Meybeck, 1982).

Particulate and dissolved organic matter can enter streams through surface water runoff or through algal and bacterial growth within the stream or lake itself. Since any organic matter is by definition more reduced than carbon dioxide, oxygen is needed in decomposition. As the organic matter is oxidized, the BOD goes down.

BOD is a measure of the organic loading in a water body. Most bacteria need organic matter to grow, and higher levels of BOD support more bacterial growth. More importantly, BOD is a measure of how much oxygen will be used up, and so can be a warning of low DO levels downstream or, in a lake at a later time. Higher BOD (>2 mg/L) in streams has a general relationship to poor water quality. High BOD itself may directly indicate sewage from homes or farms. High BOD may be indirectly caused by eutrophication that otherwise goes unnoticed and is due to leachate from septic tanks, farm runoff or recreational horse use.

BOD has only been monitored since 1999 at some of the sites in the GGNRA stables studies. Most sites were below the detection limit of 2mg/L, however, a few sites had values up around 30 mg/L, which is definitely impaired. These same sites also had noticeable fecal coliforms (900 and 1600 MPN/100mL), but compared to other sites, these would not be considered impaired by fecal coliforms, but would be considered impaired by BOD. BOD provides additional information and should continue to be monitored. At PINN, TOC has been monitored since 1997 with a median value of 8.4 mg/L and an IQR from 6.5 to 12.3 mg/L.

Nutrient Parameters

Nitrogen: Total Kjeldahl Nitrogen, Ammonia, Nitrate, Nitrite

Natural sources of nitrogen include the soil, animal wastes, and decomposing plants. The main human-influenced sources of nitrogen are sewage, fertilizers, and barnyard wastes. Sewage and barnyard wastes tend to have nitrogen primarily in the form of ammonia, while fertilizer runoff tends to have nitrogen primarily in the form of nitrate. If there is enough oxygen in the water, however, the ammonia will be converted to nitrates in the water, leading to a temporary drop in DO levels. Nitrate is very soluble and is flushed out of soils relatively quickly, while ammonia and organic nitrogen tend to be more associated with particles and surface runoff. Diel and seasonal variabilities are not anticipated nor are they very predictable.

Eutrophication increases turbidity and leads to drastic variations in the DO levels. Low DO levels act synergistically with ammonia to increase toxicity to fish. Photosynthesis during algae blooms also raises the pH, increasing the toxic fraction of ammonia.

In the past, little guidance has been available regarding acceptable levels of total nitrogen in streams, since it is a problem of accumulation in the ecosystem rather than direct toxicity to particular organisms.

Ammonia is usually considered separately since it is directly toxic. The drinking water standard is set at 10mg-N/L for nitrate, but that is much too high to be protective of many ecosystems. Recently the EPA has come out with new guidance documents for nutrient criteria development (EPA, 1999b; EPA, 1999c), including total nitrogen (TN) and total phosphorous (TP). Point Reyes National Seashore, GGNRA and Pinnacles are all included in Aggregate Ecoregion III, subecoregion 6, for which the TN reference condition is 0.5 mg-N/L based on the 25th percentile of data available for 10 streams over a 10 year period.

The TN reference condition in streams and rivers for the overall Aggregate Ecoregion III is 0.38 mg-N/L, also based on the 25th percentile over a 10 year period. EPA recommends that the criteria be based on the overall Aggregate Ecoregion reference condition, which in this case is 0.38 mg-N/L. For lakes and reservoirs, the reference condition is 0.4 mg-N/L of TN.

According to the 1995 San Francisco Bay RWQCB Basin Plan, receiving waters should not exceed an annual median of .025 mg-N/L of un-ionized ammonia or a maximum of 0.16 mg-N/L (Lee and Taylor, 1995). This is to protect against chronic toxic effects and to preclude a build up in receiving waters. EPA has also published a 1999 Update of Ambient Water Quality Criteria for Ammonia (EPA, 1999a), containing an Appendix C - Calculation of Freshwater Ammonia Criterion with a one hour CMC (criteria maximum concentration)for salmonids and not salmonids as well as a CCC (criterion continuous concentration) calculated from a thirty-day mean. These are both values for total ammonia and the calculation includes a pH as well as temperature dependence.

At PINN, nitrogen has been monitored starting in 1997, in five different parameters, field N (it is not certain if this is total N nitrate, or ammonia), Kjeldahl N, ammonia N, nitrate N and nitrite N (all measured in a certified laboratory). All of the nitrite measurements have been below the detection level of 0.5 mg/L. Most of the field N measurements were also below the detection limit of 2.5 mg/L, with a couple of samples right at the detection limit and one sample at 10mg/L. However, the field N measurements may not be reliable since, in some cases, both the field N and lab nitrate were measured for the same sample, and even though the field N was a non-detect, the lab nitrate measure was up around 5 or 6 mg/L. For the Kjeldahl N, there are only 16 samples. The median value is 0.76 mg/L, with an IQR from 0.57 mg/L to 1.55 mg/L. For ammonia, over 90% of the samples were below the detection limit of 0.1mg/L, with four samples going from 0.1 to 0.19 mg/L in 2001. Unfortunately, for two of the four samples with detectable ammonia concentrations, no pH data was collected, so it is not possible to calculate the toxic fraction. For nitrate, both the median and the lower IQR reflect the detection limits of 1.0 and 0.5 mg/L, respectively. The upper IQR is 3.2 mg/L, with values as high as 6.7 mg/L in some places.

At PRNS, nitrogen has been monitored since 1997 in the form of ammonia, nitrite, and nitrate. Over 75% of the ammonia samples were below the detection limits of 0.4 and 0.2 mg/L. The samples within the detection range went as high as 13 mg/L. Of 163 samples from 23 monitoring stations, 5 samples were associated with toxic conditions at 3 of the sampling sites. Toxic ammonia is considered a primary indicator of water quality degradation for PRNS because of its direct impact on aquatic species (Ketcham, 2001). Nitrite was mostly below the detection limits. Nitrate had a median value of 0.33 mg/L, with an IQR from 0.2 to 1.0 mg/L. Extreme values went as high as 11 mg/L. PRNS has found that stream nutrient concentrations are significantly diluted by winter flows. In several instances, tributaries showed elevated nutrient concentrations, but concentrations in the mainstem were below detection. This indicates that pollutant sources are limited within the monitored watersheds (Ketcham, 2001).

At GGNRA, nitrogen has been monitored in the forms of ammonia, nitrate, nitrite. Ammonia has been monitored since 1993. Over 60% of samples tested were below the detection limits of 0.01, 0.02 and 0.1 mg-N/L. The median value was 0.07 mg-N/L with an IQR from 0.02 to 0.1 mg-N/L. Nitrate has been monitored since 1986, with a median value of 0.8 mg-N/L and an IQR from 0.32 to 1.9 mg-N/L.

from A Review of the Water Quality Monitoring Programs in the National Parks in Central Coastal California (Stafford & Horne, 2004)

According to the WRD (STORET) report Total Ammonia as N and Nitrate and Nitrite as N have been monitored from 1986 to 1998 (data was retreived in 1999). Data fore Total Ammonia and nitrate and nitrite (combined) was plotted annually and seasonally. Results indicate no discernible annual or seasonal variability.

Within GOGA boundaries, nitrite exceeded the drinking water criterion of 1mg/L NO_2-N at Black Rock Creek and Easkoot Creek in 1994 and 1995. Nitrate plus nitrite (combined) exceeeded the drinking water criterion of 10 mg/L between 1987 and 1995 in Fitzhenry Creek.

Phosphorus: Phosphate, Total Phosphorus, Orthophosphate

Because there is no gaseous form of phosphorous, once it is in an aquatic system without a large outflow, it tends to cycle back and forth between the water column and the sediments without leaving the system (Horne and Goldman, 1994). Phosphates initially enter the system from soil sediments, fertilizer runoff, animal wastes and detergents (Creek Connections, 2004b).

Small oligotrophic streams may respond to P concentrations of 0.01 mg/L or less. In general any concentrations over 0.05 mg-P/L will have an impact, unless nitrogen is the limiting nutrient (Behar et al., 1996). Alex Horne (personal communication) sets the guideline for eutrophication in California surface waters at 0.1 mg-P/L. The recent EPA recommended total P criteria for Aggregate Ecoregion III streams and rivers is 22 ug-P/L or 0.02 mg-P/L, with a range of reference conditions from 0.01-.05 mg-P/L (EPA, 2000a). For Aggregate Ecoregion III lakes and reservoirs, the recommended criteria is set at .017 mg-P/L, with a range of reference conditions from 0.003 – 0.172 mg-P/L(EPA, 2001a). The value of 0.172 found in one of the reference sites is considered inordinately high, and EPA is planning to investigate further whether this is reflective of unique conditions, cultural enrichment or a statistical anomaly.

In the GGNRA stables study, total phosphorous grab samples were collected at every sampling event in lab-supplied bottles. Orthophosphorus (ORP) grab samples were also collected at every sampling event and stored on ice in the field. Monitoring of orthophosphorous at PRNS found only low concentrations which were not useful in determining pollution sources.

from A Review of the Water Quality Monitoring Programs in the National Parks in Central Coastal California (Stafford & Horne, 2004)

<u>Biological Indicators: Fecal coliforms, total coliforms, and *E.coli*</u>

Numeric objectives for indicator bacteria are in Tables 2 and 4 in the Introduction. These objectives are set to be protective of public health and not intended to be reflective of ecosystem health. USGS reports that the range of fecal coliforms found in uncontaminated surface waters is from < 1 to 5,000 cfu/100ml and that in fecal-contaminated surface waters, the range is from 200 to > 2,000,000 cfu/100ml. The range of *E. coli* in uncontaminated surface waters was from < 1 to 576 cfu/100ml, and in fecal-contaminated surface waters, 126 to > 2,000,000 cfu/100ml (Myers, 2003).

In general, increased fecal loading will result in higher concentrations of indicator organisms. Fecal contamination may come from ineffective management of human wastes, such as leaking septic systems or untreated wastewater. Fecal contamination also comes from poor management of animal wastes, as well as from manure from dairies and ranches. Low levels of fecal contamination also come from wildlife. Bacterial indicators are usually indicative of fecal contamination, which can contribute to low DO, excess BOD, excess ammonia, total nitrogen and phosphorous, as well as pathogenic organisms.

At PRNS, fecal coliforms have been monitored and found useful in pollutant source tracking, since nutrients are so rapidly diluted in streams. Fecal coliforms have been monitored in GGNRA since 1986, with a median of 120 cfu/100ml, and an IQR from 40 to 500 cfu/100ml. At PINN, coliforms have been monitored since 1999, with a median of 1600 MPN/100ml and an IQR of 850 to 2240 MPN/100ml. *E. coli* has also been monitored since 1999, with a median of 21 MPN/110ml and an IQR from 6 to 78 MPN/100ml.

from A Review of the Water Quality Monitoring Programs in the National Parks in Central Coastal California (Stafford & Horne, 2004)

According to the WRD Baseline Inventory and Analysis Report for PORE, the only stations with data exceeding the WRD FIB (fecal indicator bacteria; i.e., fecal or total coliforms or *E.coli*) screening limits for freshwater and marine water bathing were Home Ranch Creek and East Schooner Creek. These stations exceeded the criteria of 200 fecal coliforms (MPN)/100mL for contact recreation. Both creeks flow into Drakes Estero. There are numerous stations located in Drakes Estero but none exceeded water quality criteria. For these stations there was no annual variability (i.e., no steady increase or decline in indicator bacteria numbers); data was inconsistent. In addition, one station on Kehoe Creek had the highest concentration (> 24,000) and exceeded the contact recreation criteria for total coliforms (1000 MPN/100mL).

Within GOGA managed lands, Fitzhenry Creek , Black Rock Creek, and Easkoot Creek periodically exceeded the contact recreation criteria for total coliforms and fecal coliforms. A review of WRD data plots (including data from 1971, 1978, and 1986-1998) indicated no apparent annual or seasonal variability in fecal or total coliform concentrations. Higher concentrations would be expected in the winter rainy season if runoff was a concern; therefore, other non-point sources (septic systems) or point sources in the Stinson Beach area may be resulting in the high numbers. The range in medians for Fitzhenry Creek was 2.032 to 2.732 (log MPN/100mL) for total coliforms and 0.389 to 2.38 log MPN/100mL for fecal coliforms. At the Easkoot Creek station within park boundaries the range in medians was 2.38 to 3.38 log MPN/100mL for total coliforms and 1.699 to 2.964 log MPN/100mL for fecal coliforms. E.coli concentrations in El Polin Spring and Lobos Creek exceeded the contact recreation criteria of 126 MPN/100mL (NPS-WRD GOGA report, unpub.)

Metals

According to the WRD report, Easkoot Creek exceeded the EPA criteria for protection of aquatic life for lead (Pb), Copper (Cu), and Cadmium (Cd). Metals data was found in STORET for many other GOGA water bodies including Lobos Creek, Mountain Lake, and El Polin Spring (PRES); Redwood Creek (GOGA/MUWO), Green Gulch, Rodeo Lagoon, Gerbode Creek, and Tennessee Valley (GOGA); and Calera Creek. Cadmium exceeded acute marine (43 ug/L) and freshwater (3.9 ug/L) criterion in Rodeo Lagoon. Lobos Creek and Gerbode Valley also exceeded the acute freshwater criterion. Copper concentrations in Rodeo Lagoon exceeded acute freshwater criterion of 18 ug/L. Lead concentrations exceeded drinking water criterion of 15 ug/L in Mountain Lake (south shore) and Redwood Creek below Muir Woods. Mercury concentrations also exceeded drinking water criterion of 2.0 ug/L in Mountain Lake as well as Lobos Creek. Two nickel concentrations exceeded the drinking water criterion of 100ug/L in El Polin Spring in Feb. 1994. Zinc was a concern at several sites including stormwater runoff in the Presidio, Gerbode Valley, Tennessee Valley, Green Gulch, and Calera Creek (outside park boundaries). At these stations, 14 concentrations exceeded the acute freshwater criterion fo 120 ug/L from 1953 to 196. The highest concentration was reported in Lobos Creek.

Metals were also monitored by in PINN just downstream of the former landfill site on Chalone Creek. No metals were detected in surface water samples.

General Minerals and Alkalinity

All general minerals and alkalinity data for Chalone creek groundwater and several PINN springs met the U.S. Public Health Service Drinking Water Standards. Analytes include silica (SiO_2), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), flouride (F), nitrate (NO_3), total dissolved solids (TDS), calcium carbonate ($CaCO_3$)), pH, and specific conductance.

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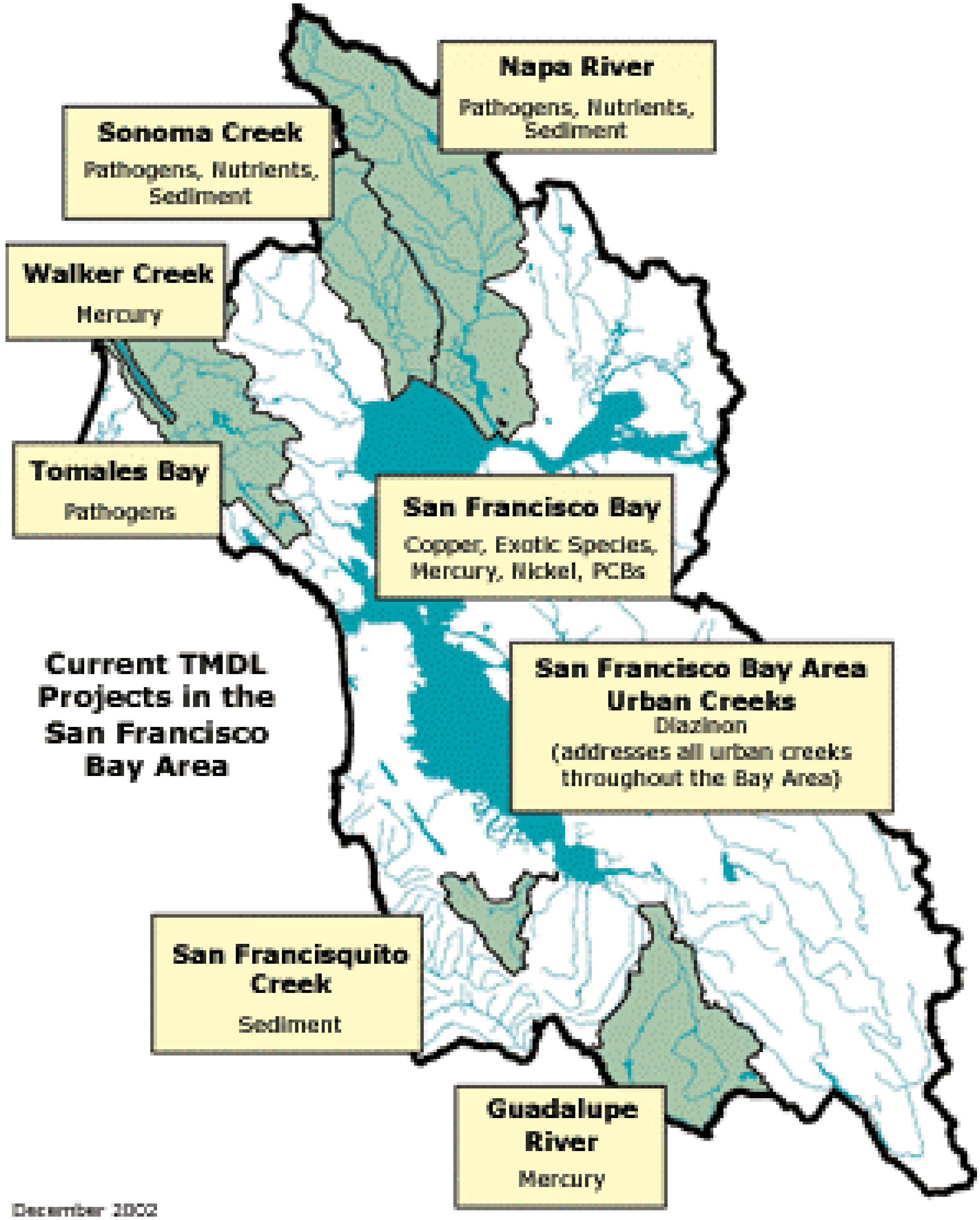
APPENDICES

APPENDIX A

2002 Clean Water Act Section 303d
List of Impaired Water Bodies
&
Current San Francisco Bay Regional Water Quality Control Board
TMDL Projects



San Francisco Bay Regional Water Quality Control Board

The California 2002 Section 303d list can be found at:
http://www.waterboards.ca.gov/sanfranciscobay/TMDL/303dlist/2002reg2303dlist.pdf

APPENDIX B

San Francisco Bay Area Regional Water Quality Control Board (SFBRWQCB)
Table of Beneficial Uses for SFAN Water Bodies

Memo from the SFAN to the SFBRWQCB: Comments on Listed Beneficial Uses of SFAN Waters

Table 1. Beneficial Uses of SFAN water bodies as determined by the San Francisco Bay RWQCB (with modifications/additions by SFAN staff in an April 2003 Memo to the RWQCB). NPS staff have made some additional changes to the table since the memo. Sets of water bodies grouped together with similar shading are located within the same greater watershed.

	AGR	COLD	COMM	EST	FRSH	GWR	IND	MAR	MIGR	MUN	NAV	PROC	RARE	REC1	REC2	SHEL	SPWN	WARM	WILD
Tomales Bay	E	E	E	E		E			E	E	E		E	E	E	E	E		E
Lagunitas Creek	E	E				E			E	E			E	E	E		E	E	E
Bear Valley Creek		E							E				E	P	E		E		E
Haggerty Gulch		E							E				E		E		E		E
Olema Creek	E	E				E							E	E	E		E	E	E
Pacific Ocean			E				E	E	E		E		E	E	E	E	E		E
Santa Maria Creek		E							E				E	P	E		E	E	E
Coast Creek		E							P				P	E	E		E		E
Alamere Creek														P	E		E		E
Crystal Lake														P	E		E	E	E
Arroyo Hondo		E							P				E	P	E		E		E
Limantour Estero		E	E	E				E	E				E	P	E	E	E		E
Glenbrook Creek		E	E	E				E	E				E	P	E		E		E
Muddy Hollow		E	E	E				E	E				E	P	E		E		E
Kehoe Lagoon														E	E			E	E
Abbott's Lagoon								E						E	E			E	E
Drakes Estero		P	E	E				E	E				E		E	E	E		E
East Schooner Ck.		P							P				P				P		E
Home Ranch Creek		E							E				E		E		E		E
Bolinas Lagoon			E					E	E		E		E	E	E	E	E		E
Pine Gulch		E							E				E		E		E		E
McKinnan Gulch		E							E				E		E		E		E
Morses Gulch		E							E				E		E		E		E
Pike County Gulch		E							E				E		E		E		E
Stinson Gulch		E				E			E	E			E		E		E		E
Easkoot Creek		E							E	E			E		E		E		E
Webb Creek		E								E							E		E
Lone Tree Creek																			E
Redwood Creek	E	E				E			E	E			E	E	E		E		E
Tennessee Valley	E	E							E						E		E		E
Rodeo Lagoon				E									E		E		E	E	E
Rodeo Creek		E											E		E		E		E
Nyhan Creek															E			E	E
San Francisco Bay			E	E			E	E	E		E	E	E	E	E	E	E		E
West Union Creek		E				E			E				E		E		E		E
Lobos Creek						P			P	E					E		E	E	E
Mountain Lake						P									E			E	E
San Pedro Creek		E							E	E					E		E		E
Walnut Creek		E							E					P	E		E	E	E
Alhambra Creek		P							P	E			P	P	E		E	E	E

P – Potential Beneficial Use

E – Existing Beneficial Use

U.S. Government
Memorandum

To: Steve Moore, Section Leader
Policy and Planning Section
San Francisco Bay Regional Water Quality Control Board

Cc: Tamara Williams, Brannon Ketcham

From: Mary Cooprider
Water Quality Specialist
San Francisco Bay Area Network
National Park Service

Date: April 18, 2003

Re: Update of Waterbodies and Beneficial Uses in the San Francicso Bay Water Quality Control Plan (Basin Plan)

The following comments are provided in reference to your March 18, 2003 memo soliciting input for revision of the Basin Plan. These comments refer primarily to streams within the San Francisco Bay Area National Parks including: Point Reyes National Seashore, Golden Gate National Recreation Area, Muir Woods National Monument, The Presidio of San Francisco, and John Muir National Historic Site. Suggested stream names and beneficial uses can be justified based on USGS topographic maps, park maps, existing natural resources, land use, and history of the parks. Further information supporting these comments can be obtained by personal communication with park staff, from park General Management Plans, and from a wide array of both published and unpublished documents. Tamara Williams (Hydrologist at Golden Gate National Recreation Area), Brannon Ketcham (Hydrologist at Point Reyes National Seashore), and I will be available for consultation regarding these comments. Please direct initial questions or concerns to me at (415) 464-5122 or mary_cooprider@nps.gov.

Water Body Names and Locations

These changes and additions are provided with the knowledge that not all of these water bodies may be listed separately in the final plan.

Marin Coastal Basin Figure 2-3 nad Table 2-1
First Valley Creek should be named East Schooner Creek.
Change Gulch Creek to Haggerty Gulch.
Add Stinson Gulch and Webb Creek (Bolinas Bay watershed).
Add Lone Tree Creek and Tennessee Valley Creek (Pacific Ocean watershed).
Add Bolinas Bay and Drakes Bay.
Add Muddy Hollow and Glenbrook Creek (Limantour Estero watershed).
Add Santa Maria Creek and Arroyo Hondo (Pacific Ocean watershed).
Pine Gulch Creek should be listed in the Bolinas Bay watershed (not Lagunitas Creek watershed).

San Mateo Coastal Basin Figure 2-4 and Table 2-2
Add Milagra Creek
Add Half Moon Bay

Central Basin Figure 2-5 and Table 2-3
Add Nyhan Creek (flows into Coyote Creek/Richardon Bay)
Add Lobos Creek (flows into Pacific Ocean).
Add Mountain Lake.

Add Crissy Field Lagoon.

<u>South Bay Basin Figure 2-6 and Table 2-4</u>

Add West Union Creek.

<u>Suisun Basin Figure 2-9 and Table 2-7</u>

Add Alhambra Creek (and Franklin Creek?)

General Comments on Waterbody Tables and Basin Maps

The use of the term "estuary" as a Waterbody Type is not consistent with the definition of "Estuarine" as a Beneficial Use. Definitions of Waterbody Type would be helpful.

A clarification of COLD and WARM beneficial use categories would be helpful. Are COLD and WARM mutually exclusive? Is it assumed that a stream with a COLD Beneficial Use also includes WARM? (This is what we have assumed in our specific comments below). The aquatic habitat values for the WARM classification are not really temperature based. Is the Board using limits to determine whether a habitat is COLD or WARM (e.g., below 65 degrees Fahrenheit for COLD)? Also, there are cold water streams that do not support anadromous fish. Should COLD be indicated only as a beneficial use when either rainbow trout, steelhead trout, or coho salmon are known to be present?

The level of detail for each watershed should be similar. It isn't clear why some tributaries are classified individually and others are not. In Table 2-1, Limantour Estero has no tributaries listed below it; Drakes Estero has one of its tributaries. Tomales Bay and Bolinas Bay are included in Table 2-1 Basin 1- Marin Coastal Basin, but Drakes Bay is not. The USGS hydrologic unit code name for the Point Reyes National Seashore watersheds is the Drakes Bay-Tomales Bay unit. For this, and other reasons, excluding Drakes Bay from a State watershed map (when other bays are included) may not be appropriate. What is the basis for determining which bays are included?

<u>Table 2-1 Basin 1 – Marin Coastal Basin</u>

Unless otherwise noted, we concur with the Beneficial Uses designated in the 1995 Basin Plan. The following are additions or deletions to the existing tables.

Pacific Ocean (Marin) (Point Reyes National Seashore)

Abbott's Lagoon – WARM (E)

Drakes Estero – COLD (E); EST (E); MIGR (E); RARE (E); SHEL (E); SPWN (E)

East Schooner Creek (change from First Valley Creek) - COLD (P); MIGR (P); RARE (P); SPWN (P); SHEL does not apply

Home Ranch Creek – COLD (E); MIGR (E); RARE (E); REC-2 (E); SPWN (E); WILD (E)

Santa Maria Creek – COLD (E); MIGR (E); RARE (E); REC-1 (P); REC-2 (E); SPWN (E); WARM (E); WILD (E)

Coast Creek – SHEL does not apply; MIGR(P); RARE (P)

Alamere Creek – COLD does not apply as it relates to fisheries but it is cold water habitat; a waterfall prohibits anadromous fish migration; SPWN (E)

Crystal Lake - COLD does not apply (there are no anadromous fish)

Arroyo Hondo - COLD (E), MIGR (E), RARE (E); REC-1 (P); REC-2 (E); SPWN (E); WILD (E)

Limantour Estero – COLD (E); EST (E); MIGR (E); SHEL does not apply

Table 2-1 Basin 1 – Marin Coastal Basin (cont.)

Glenbrook Creek (same as Limantour Estero)

Muddy Hollow (same as Limantour Estero)

Pacific Ocean (Marin) (Golden Gate National Recreation Area)

Lone Tree Creek – WILD (E)

Bolinas Bay (shown in Table 2-1 but not on Figure 2-3)

Bolinas Lagoon – NAV (E)

Easkoot Creek – COLD (E); MIGR (E); MUN (E); RARE (E); REC-2 (E); SPWN (E); WILD (E)

McKennan Gulch Creek - COLD (E); MIGR (E); RARE (E); REC-2 (E); SPWN (E); WILD (E)

Morses Gulch Creek - COLD (E); MIGR (E); RARE (E); REC-2 (E); SPWN (E); WILD(E)

Pike County Gulch Creek – COLD (E); MIGR (E); RARE (E); REC-2 (E); SPWN (E); WILD (E)

Stinson Gulch Creek - COLD (E); GWR (E); MIGR (E); MUN (E); RARE (E); REC-2 (E); SPWN (E); WILD

Webb Creek – (Perennial, not intermittent) COLD (E); MUN (E); SPWN (E); WILD (E)

Pine Gulch Creek - add as part of Bolinas Bay watershed (not Lagunitas Creek Watershed).
COLD (E); MIGR(E); RARE (E); REC-2 (E); SPWN (E); WILD (E)

Redwood Creek (Marin) – FRSH does not apply; GWR (E); MIGR(E); RARE (E); SHEL does not apply;
WARM (E) (should this be deleted since this stream has COLD beneficial uses?)

Green Gulch Creek – AGR (E); COLD (E); GWR (E); MIGR (E); RARE (E); REC-2 (E); SPWN (E);
WARM? (E – would apply to storage ponds in this subwatershed); WILD (E)

Tennessee Valley Creek – AGR (E); COLD (P); MIGR (P); REC-2 (E); SPWN (E); WARM (E); WILD (E)

Rodeo Lagoon – EST (E); RARE (E); REC-2 (E); SPWN (E); WARM (E); WILD (E)

Rodeo Creek – MAR does not apply; REC-1 does not apply

Tomales Bay – AGR (E); COLD (E); COMM (E); EST (E); GWR (E); MIGR (E); MUN (E); NAV (E); RARE (E);

REC-1 (E); REC-2 (E); SHEL (E); SPWN (E); WILD (E)

Lagunitas Creek - GWR (E)

Bear Valley Creek – COLD (E); MIGR (E); RARE (E); REC-1 (E); REC-2 (E); SPWN (E); WILD (E)

Gulch Creek (change to Haggerty Creek) - COLD (E); MIGR (E); RARE (E); REC –2 (E); SPWN (E);
WILD (E)

Olema Creek - MAR is not applicable; AGR (E); GWR (E); RARE (E); REC-1 (E)
WARM (should this be deleted since this stream has COLD beneficial uses?)

Table 2-2 Basin 2 – San Mateo Coastal Basin

Pacific Ocean (San Mateo, San Francisco) – COMM (E); MAR (E); MIGR (E); NAV (E); RARE (E); REC-1 (E); REC-2 (E); SHEL (E); WILD? (E)

Milagra Creek (add to Figure 2-4) – WARM (E); MIGR (P); RARE (E); WILD (E)

Table 2-3 Basin 3 – Central Basin

Golden Gate Channel - COMM (E); MAR (E); MIGR (E); NAV (E); RARE (E); REC-1 (E); REC-2 (E); SHEL (E); WILD (E)

Crissy Field Lagoon – REC-2 (E); WILD (E)

Lobos Creek (flows to Pacific Ocean) – Perennial (not Intermittent); GWR (P); MIGR (P); MUN (E); REC-2 (E); SPWN (E); WARM (E); WILD (E)

Mountain Lake – (not Reservoir); GWR (P); REC-2 (E); WARM (E); WILD (E)

Richardson Bay - Add Nyhan Creek to Fig. 2-5

Nyhan Creek – WARM (E); WILD (E); We are not certain what beneficial uses exist downstream of Oakwood Valley.

Table 2-3 Basin 4 - South Bay Basin

Lower Crystal Springs Reservoir – FRSH (E)

Upper Crystal Springs Reservoir – FRSH (E)

San Andreas Lake – FRSH (E)

West Union Creek – Intermittent (not Perennial); COLD (E); GWR (E); MIGR (E); RARE (E); REC-2 (E); SPWN (E); WILD (E)

Table 2-7 Basin 7 - Suisun Basin

Alhambra Creek – COLD (P); MIGR (P); MUN (E); RARE (P); REC-1 (P); REC-2 (E); SPWN (P); WARM (E); WILD (E)

Note: Franklin Creek (tributary of Alhambra) has cold water temperatures and gravel substrate sufficient to support spawning salmonids. Reports of spawning salmonids in Alhambra have been made, but there is no definitive evidence. Steelhead trout were caught in the creek in 1999 and dead salmon have been found. Salmonid sightings may be attributed to spawners "wandering" from their intended destination (this was suggested by the California Department of Fish and Game and cited in the Alhambra Creek Watershed Management Plan).

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APPENDIX C

NPS May 2002 Memo:
Development of Park Vital Signs Monitoring Programs
and Integration of Water Quality Monitoring

May 2, 2002

N16 (2300)

Memorandum

To: Regional Directors
Attention: Regional I&M Coordinators

From: Associate Director, Natural Resource Stewardship and Science /s/
Abigail Miller, for

Subject: Development of Park Vital Signs Monitoring Programs and Integration of Water Quality Monitoring

In FY 2002, 12 vital signs monitoring networks that include 101 parks received funding to plan and design an integrated natural resource monitoring program, and 5 additional networks that include 52 parks received $150,000 start-up funds for planning and design work. A document entitled the *National Park Service's Vision and Implementation Strategy for Park Vital Signs Monitoring* that describes the monitoring planning and design efforts was provided to you in October 2000. A memorandum describing the integration of the water quality and air quality monitoring components with the core vital signs component was provided to you on December 21, 2000. Please contact the Inventory and Monitoring Program Office in Fort Collins, Colorado at (970) 225-3539 if you need an additional copy of those documents.

The development of network monitoring programs is a complex and difficult process that requires a front-end investment in planning and design to ensure that monitoring will meet the most critical information needs of each park and produce scientifically credible data that are accessible to managers and researchers in a timely manner. The investment in planning and design also ensures that monitoring will build upon existing information and understanding of park ecosystems and make maximum use of leveraging and partnerships with other agencies and academia. Based on our experience to date, and that of other agencies, it is important that networks receive peer review of some of the initial work and decisions made in identifying potential vital signs for natural resource monitoring before the detailed design and protocol development work is done. Accordingly, all networks receiving funding for vital signs monitoring will be required to follow a 3-phase approach to the planning and design efforts that includes peer review and approval of each phase through the Regional office, as described in the attached document. The document also includes the implementation schedule for this approach, as well as the required format for network monitoring plans.

The implementation plan for the water quality monitoring component that is being funded by the Water Resources Division is keyed to the concept of fully integrating the design and implementation of water quality monitoring with the network-based vital signs monitoring program being developed by the Natural Resources Information Division. Accordingly, networks should incorporate the 3-phase approach and follow the same implementation schedule for their water quality monitoring planning. Networks have the option of producing a single, integrated monitoring plan that follows the outline in the attached document, or they can produce a separate document for the water quality monitoring component that follows the detailed guidance for water quality monitoring developed by the Water Resources Division for the Vital Signs handbook (available at http://www.nature.nps.gov/im/monitor/handbook.htm).

Thank you for your continued support of the Service's ecological monitoring efforts. If you have questions or need additional information about the activities described above, please contact Dr. Gary Williams, the Servicewide Inventory and Monitoring Program Manager at (970) 225-3539, or Steven Fancy, the National Monitoring Coordinator at (970) 225-3571. Questions specific to the water quality monitoring component should be directed to Bill Jackson (970) 225-3503 or Gary Rosenlieb (970) 225-3518.

Attachment

Development of Park Vital Signs Monitoring Programs
and Integration with Water Quality Monitoring

Peer review of the initial network information, analysis and decisions made in identifying potential vital signs for natural resource monitoring is required before the detailed design and protocol development work is done. Accordingly, this document describes a phased approach to the planning and design efforts, the implementation schedule, and the required format for network monitoring plans.

Networks may produce a single, integrated monitoring plan that included water quality monitoring, or a separate document for the water quality monitoring component that follows the detailed guidance for water quality monitoring developed by the Water Resources Division for the Vital Signs handbook (http://www.nature.nps.gov/im/monitor/handbook.htm).

1. <u>Servicewide goals for vital signs monitoring</u>

The following Servicewide goals for vital signs monitoring should be included in all network monitoring plans. The weighting placed on various goals may differ among networks, and some networks may choose to add additional network-specific goals, but it is proposed that these goals for vital signs monitoring should apply Servicewide:

- Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
- Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
- Provide a means of measuring progress towards performance goals.

2. <u>Three-phase process for development of network monitoring plans:</u>

The Phase 1 report should describe the formation of the network Board of Directors and science/technical committees and the results of the work involved in summarizing existing data and understanding of the park ecosystems, defining goals and objectives for the monitoring, developing draft conceptual models, and other background work that should be done before the initial selection of vital signs. The report includes most of the tasks and data compiled during Steps 1 and 2 and part of Step 3 of the 7-step "Recommended approach for developing a network monitoring program" that was included with the October 13, 2000 memo "New Park/Network Monitoring Program: Vision and Implementation Plan". A description of the 7-step approach can be downloaded from http://www.nature.nps.gov/im/monitor/approach.htm. The material developed during these steps forms the basis for Chapters II and III of the monitoring plan, as described in the attached outline. Networks should draft these two chapters of the plan and have them peer reviewed and approved by the regional I&M coordinator before selecting and prioritizing their vital signs or doing more detailed design and protocol development work.

The peer review should focus on the scientific basis for the planning and design of the network monitoring program. The Regional I&M coordinator will be responsible for selecting at least three peer reviewers for this phase of the planning and design work.

Some of the details that will be included in the final monitoring plan, such as identification of specific, measurable objectives and threshold values or "trigger points", will be developed later in the process and therefore will not be included in the Phase 1 report. The 3-phase design process is an iterative process, and the final monitoring plan will "cut and paste" much of the material from the Phase 1 report, but will include additional detail that is developed during Phase 2 and 3 of the design process.

The report for Phase 2 of the monitoring design will update and expand upon the material in Chapters II and III of the monitoring plan, but will also include the results of one or more scoping workshops and subsequent review to identify and do an initial prioritization of potential vital signs for natural resource monitoring. This involves parts of Step 3 as well as Step 4 of the 7-step recommended approach. The Phase 2 report should be a draft of Chapters II, III and IV of the monitoring plan, as described in the attached outline.

The Regional I&M Coordinator will also be responsible for selecting reviewers for the second phase of the work. Peer review for this phase of the work should include a management perspective as well as the scientific basis for the monitoring program. The report on this phase of the planning and design work will satisfy the requirements for meeting Performance Management Goal 1b3 "Vital Signs" for all parks in the network once it has been peer reviewed and approved by the Regional I&M Coordinator.

Phase 3 involves more detailed design work needed to draft the full monitoring plan as described in the attached monitoring plan outline. This may include a revision of priorities for vital signs monitoring to fit within budgets and to make efficient use of personnel once decisions on staffing and funding are made. This phase involves Steps 5, 6 and 7 of the 7-step recommended approach. The monitoring plan should include all of the chapters and appendices listed in the outline for the monitoring plan. The peer review process for this step will be addressed separately at a later time.

3. Implementation schedule for 3-phase process:

From the date that planning funds for vital signs monitoring are first made available, networks are expected to complete Phase 1 within 1-1/2 years, complete Phase 2 within 2 years, and submit a draft of the full monitoring plan within 3 years. The first 12 networks have been given an extra six months because of initial startup difficulties with getting coordinators and data managers hired and getting the program up and running.

Networks funded in FY01 (5 networks/55 parks):

Phase 1 -	October 1, 2002
Phase 2 -	April 1, 2003
Phase 3 -	April 1, 2004

Networks receiving planning funds in FY01 (7 networks/46 parks):
Phase 1 - October 1, 2002
Phase 2 - April 1, 2003
Phase 3 - April 1, 2004

Networks receiving planning funds in FY02 (5 networks/52 parks):
Phase 1 - April 1, 2003
Phase 2 - October 1, 2003
Phase 3 - October 1, 2004

4. Outline and format for network monitoring plans

Each network of parks that receives funding from the Natural Resource Program Center to develop a monitoring program is required to prepare a monitoring plan describing the monitoring program and the various tasks and decisions that contributed to the final selection of indicators to be monitored. Sections of the monitoring plan will need to be peer reviewed and approved before the network is approved to continue with the development of the monitoring program, and the full monitoring plan that contains all of the material in the following outline will require peer review and approval before it is fully implemented. Monitoring plans should follow the outline below (network monitoring plans should include all of the chapters listed below, but networks are free to organize material within each chapter as appropriate to make the plan more easily understood and organized).

I. Executive Summary

II. Introduction and Background

- Explain the purpose of the monitoring program, including a summary of legislation, NPS policy and guidance, Servicewide and network-specific goals for monitoring, Servicewide and park-specific strategic goals for performance management that are relevant to the monitoring, and any statements from park enabling legislation that establish the need to monitor natural resources. Answer the question, "who is interested in the information provided by monitoring, and why?"
- List the objectives of the monitoring, including specific, measurable objectives bounded in space and time wherever possible.
- Give an overview of each park and its natural resources. More detailed descriptions of each park and its resources could be included in an appendix. What is the importance of the park's natural resources in a regional or national context? For water quality monitoring, identify parks that have waters where constituents exceed water quality standards and are listed on state Clean Water Act 303d lists or constituents that may be threatened to become degraded. Also identify parks that have waters designated as Outstanding National Resource Waters or other special protective designations in their state water quality standards. Draft guidance for identifying these waters is contained in the Vital Signs Monitoring Handbook
- What are the most important management issues and scientific issues for each park? What are the most important agents of change and stressors that may cause changes in park resources?
- Give an overview of natural resource monitoring that is currently being done in each park or that occurred previously. Describe any widely-accepted monitoring efforts used in the general region by other agencies that provide opportunities for data comparability (putting the network's data in context and assisting in interpretation of data collected in parks).
- Describe the overall process used to determine the goals and specific measurable objectives for the monitoring program, and to select the vital signs for monitoring park resources and providing the information needed to manage the parks.

III. Conceptual Models

- Provide a summary of the understanding of the park ecosystem, including conceptual models developed prior to and during the scoping process. This summary should focus on aspects of the ecosystem that are relevant to the monitoring program. Guidance and examples of conceptual models can be found at http://www.nature.nps.gov/im/monitor.
- -

(Note: Most of the background material and development of conceptual models described in Chapters II and III should be written up in a Phase 1 report, peer-reviewed, and approved by the regional I&M coordinator before the network selects and prioritizes its vital signs. The Phase 1 report may not include some material that may not be developed until later in the design process, such as specific, measurable objectives and threshold values or "trigger points").

IV. Vital Signs

- List the vital signs selected for monitoring, the justification for why they were selected, and show how they fit with the conceptual ecosystem model. Provide a list or table describing the vital signs that were considered but not selected for monitoring and the reasons why they were not selected.
- Provide the results of scoping workshops and other efforts to identify the most important issues and data needs for parks in the network, and the criteria or process used to determine which components would be included in the monitoring program. For water quality plans, identify pollutants that exceed water quality standards. Specific guidance for other water quality constituents that may serve as vital signs indicators is contained in the Vital Signs Monitoring Handbook (In development).
- List the specific, measurable objectives for each vital sign selected for monitoring, and wherever possible, give the threshold value or "trigger point" at which some action will be taken. The statistical "detection limits," given typical sample variability and chosen sample sizes, shall be low enough to insure that such threshold values or trigger points can be detected.

- -

(Note: A second round of peer review and approval of the Phase 2 report should occur after the initial list of vital signs and measurable objectives is determined, and prior to detailed work on sampling design, protocol development, database design, etc.)

V. Sampling Design

- Explain the need for an overall statistical sampling design that allows inferences to be made to areas larger than those actually sampled. Identify specific populations to be monitored, and sampling units.
- For each park, describe the approach used to determine where sampling will occur for each vital sign, including justification for collocating or not collocating sampling for various vital signs. Provide justification for the attributes used to stratify the park into sample units (e.g., cost of access, terrain features such as elevation and slope, soils or vegetation map). Describe what is known about average values and variability in the various strata and how the sampling scheme will insure that the value obtained will be representative of the target population being studied. If the variability and typical values in various potential strata is not well understood, typically pilot scale monitoring should be initiated to determine these values before the monitoring design is finalized.
- Detailed maps and descriptions of where samples will be taken can be included in the protocols or an appendix, but summarize the overall spatial design for each park here.

VI. Sampling Protocols

- Give an overview of each sampling protocol that will be used to monitor the vital signs. The full protocols should be included in an appendix. The overview should summarize the material in the Protocol Narrative for each protocol, including an overview of the resource issue being addressed, specific measurable objectives, sampling design, field methodology, data analysis and reporting, personnel requirements, and operational requirements. Generally accepted Standard Operating Procedures for the collection of data for constituents that may serve as water quality vital signs are provided in the Vital Signs Handbook (In development). Standard Operating Procedures (SOPs) used should be those that insure that the data are comparable with other large regional data sets, to the extent possible. Protocols should include a detailed discussion of Quality Assurance/Quality Control measures used to insure that data collected will be considered credible by those who will be using it, including NPS managers, state agencies, and other federal agencies.

VII. Data Management

- Overview of the process for entering, editing, storing, and archiving data collected by the various components of the monitoring program, including metadata procedures. See the Vital Signs Monitoring Handbook (In development) for special requirements for entering and managing water quality data in the Environmental Protection Agency's STORET database. The full Data Management Plan should be attached as an appendix.
- Provide an overview of the database design for the monitoring program.

VIII. Data Analysis and Reporting

- Describe how data collected by the monitoring program will be analyzed, including who is responsible and how often analysis will occur.
- Describe the various reports and other products of the monitoring effort, including what they will include, who the intended audience is, how often they will be produced and in what format, and who will be responsible for ensuring that data are analyzed and reported in a timely manner.

IX. Administration/Implementation of the Monitoring Program

- Describe the makeup of the Board of Directors and Science/Technical committees for the network of parks, and their role in developing the monitoring strategy and implementing and promoting accountability for the monitoring program.
- What is the staffing plan for the monitoring program? Who will be involved in the program, where will be they be stationed, and what is their role in the program?
- Integration with other park operations: describe how the monitoring program integrates with other park operations such as interpretation, law enforcement, and maintenance.
- Partnerships: Describe other agencies and individuals that are part of the monitoring program. List cooperative agreements and other partnership agreements that are in place.
- For field sampling efforts to be performed in house, describe how they will be supported in terms of staff training and/or previous experience, field equipment to be dedicated to the effort (vehicles, instruments), anticipated in-house lab work to support operation, maintenance, and calibration of equipment and its documentation, and the necessary safety considerations in performing field tasks. (Note: each Network may want to standardize their own Safety Plan to cover monitoring efforts, particularly in regard to water quality sampling)
- Periodic Reviews: explain the process and schedule for periodic reviews of the overall program and various components and protocols.

X. Schedule

- Summarize the frequency of sampling for the various components of the monitoring program (e.g., during what season of the year, and whether sampling should occur annually or once every several years.)
- Identify the target completion date for protocols still to be developed, or for other tasks that will require additional time to complete before a component of the monitoring will be implemented.

XI. Budget

XII. Literature Cited

XIII. Appendices

- Detailed descriptions of parks and their resources (optional)
- Workshop reports
- Sampling Protocols
- Database design details
- Data Management Plan

APPENDIX D

San Francisco Bay Area Network (SFAN)
Water Quality Planning Meeting Attendees

JOMU/EUON (March 2003)
Glenn Fuller (JOMU/EUON/POCH Superintendent)
Susan O'Neil (SFAN Biologist)
Igor Skaredoff (member/chair Friends of Alhambra Creek)
Brian Garrett (JOMU Maintenance)
Brannon Ketcham (PORE Hydrologist)
Tamara Williams (GOGA Hydrologist)

GOGA/MUWO (March 2003)
Tamara Williams (GOGA Hydrologist)
Darren Fong (GOGA Aquatic Ecologist)
Daphne Hatch (GOGA Chief of Resource Management)
Carolyn Shoulders (GOGA Biologist/Planner)
Brannon Ketcham (PORE Hydrologist)
Mia Monroe (MUWO Administration/Interpretation)
Pat Reischl (GOGA Maintenance)
Brian Ullensvang (GOGA Environmental Engineer)
Tony DiStefano (GOGA Environmental Protection Specialist)
Laura Castellini (GOGA Environmental Protection Specialist)
Terri Thomas (Presidio Trust-Natural Resources)
Susan O'Neil (SFAN Biologist)
Brian Witcher (SFAN Data Manager)
Sarah Stafford (UC Berkeley)
Alex Horne (UC Berkeley)
Melanie Wollenweber (GOGA Civil Engineer)

PINN (Nov. 2002)
Cicely Muldoon (PINN Superintendent)
Tom Leatherman (PINN Chief of Natural Resources)
Chad Moore (PINN Geologist/Hydrologist)
Minda Troost (PINN Hydrologic Technician)
Darrel Chambers (PINN Chief of Maintenance)
Jeff Weeks (PINN Maintenance)
Bill Arkfeld (Central Coast Regional Water Quality Control Board)

PORE (April 2003)
Don Neubacher (PORE Superintendent)
Ed Walls (PORE Chief of Maintenance)
Brannon Ketcham (PORE Hydrologist)
Lorraine Parsons (PORE Wetland Ecologist)
Sarah Allen (PORE Marine Biologist, Network Science Advisor)
Becky Tuden (Regional Water Quality Control Board/County of Marin)
Mark Homrighausen (PORE Range Management)
David Lewis (UC Extension)
Dale Hopkins (Regional Water Quality Control Board)
Sarah Stafford (UC Berkeley)
Darren Fong (GOGA Aquatic Ecologist)
Leslie Allen (PORE Wetland Ecologist)

PRES (March 2003)
Terri Thomas (Presidio Trust, Resource Management)
Kristen Ward (GOGA Ecologist)
Daphne Hatch (GOGA Chief of Resource Management)
Tamara Williams (GOGA Hydrologist)
Arlene Navarette (City and County of San Francisco)
Brian Ullensvang (GOGA Environmental Engineer)
Laura Castellini (GOGA Environmental Protection Specialist)
Tony DiStefano (GOGA Environmental Protection Specialist)
Jennifer Coats (Presidio Trust Environmental Remediation Specialist)

APPENDIX E

San Francisco Bay Area Network (SFAN)
Water Quality Planning Meeting
Discussion Questions

JOMU/EUON WATER QUALITY PLANNING MEETING DISCUSSION

Desired Outcome*: Gather needed information so that key issues can be identified and discussed. Address monitoring questions, establish objectives based on key issues, and begin the prioritization process.*

Land Use & Natural Resources

1. Where are equestrian operations located within park watersheds?
2. Where is there cattle grazing within park watersheds?
3. Is there documentation of salmonids or other T& E species in the watersheds?
4. Are there maps of wells and springs?
5. Where do water withdrawals occur?
6. Is there a roads and trails inventory for JOMU (including culvert crossings)?

Facilities & Utilities

1. Where are the stormwater outfalls and their drainage basins?
2. Is there known or suspected contamination from sewer systems or storm drain overflows?
3. Are there stormwater monitoring requirements for these parks?
4. Do we have documentation of all septic systems and leachfields located on (or adjacent to) parklands?
5. Is there known or suspected contamination (fecal bacteria, nutrients, MBAS) from septics?
6. Does the park treat any of its water?
7. To where do the parking lots drain?
8. Is there known or suspected contamination from parking lots?
9. Where are vehicles washed?

Wastes & Contaminants

1. What is the chemical application policy?
2. What lands have pesticide application? Orchards?
3. What types of chemicals are used in the park (include name and purpose)?
4. Where are hazardous wastes stored?
5. Are there any landfills on park lands?
6. Are there suspected issues with heavy metals in water?

Water Quality Monitoring

1. What types of monitoring efforts are on-going or have occurred in park watersheds?
2. What is our level of involvement with outside agencies?
3. What WQ data (tech. support) is needed to support the existing projects (e.g., Franklin Creek Restoration, Mt. Wanda dam removal, and Mt. Wanda sub-watershed management plan?
4. What do you see as the priority water resources to monitor for water quality?
   Franklin Creek
   Strentzel Canyon (Sub-drainage Zone No. 1167)
   Alhambra Creek
   EUON (Las Trampas) stock pond, spring (NPS owned?), small drainage adjacent to HQ
5. What resources are available to implement the monitoring?

GOGA/MUWO WATER QUALITY ISSUES AND DISCUSSION QUESTIONS

***Desired Outcome**: Gather needed information so that key issues can be identified and discussed. Address monitoring questions, establish objectives based on key issues, and begin the prioritization process.*

Bacteria and Nutrients

1. Do we have documentation of all septic systems and leachfields located on parklands?
2. Is there known contamination (fecal bacteria, nutrients, MBAS) from septics?
3. Do we know what the sources of phosphorus in park watersheds are?
4. Is nitrogen a problem in surface waters within the park?
5. Where are the most significant incidences of elevated pH, elevated temperature, low dissolved oxygen (or other parameters that may be related to high nutrient levels)?
   (e.g., Rodeo Lagoon)
6. What is our relationship with stable operators?
7. Do sustainable stable operations exist?
8. Who implements the stable management practices (the park or the stables?)

T & E Species Habitat Requirements

1. Are there known incidences of poor water quality effecting T & E species?
2. What are the water quality related habitat requirements for T & E species?

Public Health

1. Where does water-contact recreation (swimming, etc.) occur?
2. What beach water quality monitoring is being done? Where and by whom?
3. What is the frequency and period of record for beach monitoring?
4. What beach monitoring reports have been produced (or will be produced?)
5. Do park users (hikers, back-packers, etc.) drink the water directly from streams?

Sanitary Sewer/Storm Drains

10. Where are the stormwater outfalls and their drainage basins?
11. Is there known contamination from sewer systems or storm drain overflows?
12. What are the stormwater monitoring requirements for the park?

Water Rights/ Groundwater Pumping

1. Is there documentation of where water withdrawal occurs?
2. Are there wells and springs maps?
3. Is there a dam/reservoir inventory?
4. Are there issues with the public water systems that affect the ecological quality of NPS waters (e.g., flushing of systems with chlorine and discharge into waters)?

Parking Lots

1. Is there a parking lot inventory?
2. Is there known contamination from parking lots?
3. Where are the vehicle washes? To where does the runoff flow?
4. Are there any monitoring activities around parking lots?

Sediment and Erosion

1. Is there a roads and trails inventory?
2. Is there an inventory of road crossings (culverts)?
3. Is there a landslide inventory?
4. What streams have been channelized? When?
5. What are the issues with controlled burns?
6. To what extent to recreational land uses (off-road vehicles, hikers, horses, etc.) contribute to erosion and sediment problems?
7. What are the <u>major</u> sources of sediment? Where are they?

GOGA/MUWO WATER QUALITY ISSUES AND DISCUSSION QUESTIONS
(Continued)

Pesticides/Chemicals
1. What is the chemical application policy?
2. What lands have pesticide application?
3. Is there documentation of where and why pesticide application occurs?
4. What types of chemicals are used (include name and purpose)?
5. What is the status (clean-up efforts, etc.) of the Alcatraz dredge material site?
6. What are the known incidences of contamination in surface or groundwater?

Landfills/Waste
1. Is there an inventory of wastes?
2. Where are hazardous wastes stored?
3. Do we have documentation/maps of landfill locations?
4. What are the issues associated with the landfills?
5. Does the park manage the fills or any clean-up activities?

Mines/Quarries
1. Is there a mine/quarry inventory?
2. What types of mines/quarries are there within park boundaries?
3. Are there known water quality issues related to mines or quarries?

Heavy Metal Contamination
1. What is the level of contamination of cadmium, lead, copper, iron, silver, & selenium?
2. What are the sources?
3. What other heavy metals have been found in park waters?
4. Should heavy metals be monitored in surface water?
5. Do we know the extent of contamination in groundwater and surface water?
6. What are the current groundwater monitoring activities?

Management Practices (Corrective Actions)
1. What management practices (BMPs) related to water quality are currently being implemented? (e.g., stormwater management practices, agricultural management practices)
2. Are the management practices effective (do we have data to show this)?
3. Are there other management practices that we want to implement but have not?
4. What are the restrictions to implementation?
5. What construction water quality BMPs have been developed?
6. What construction BMPs are required of contractors and park work?
7. Are there watershed management plans (NPS or outside agencies)?
8. Have special protection areas within watersheds been established?
9. Has the park worked with other agencies (e.g., Regional Water Quality Control Board, UC Extension) to establish management practices?

Water Quality Monitoring
1. Who is interested in the information provided by monitoring?
2. Are there known monitoring efforts by non-NPS entities? (e.g., Surfriders)
3. Do we know of, or have access to, data collected by non-NPS entities?
4. What is our involvement with outside agencies?
5. Who has coordinated with other agencies and on what issues and why?
6. Are there community outreach activities related to water quality?
7. To what extent are we concerned with ocean and bay water monitoring?
8. What resources are available to implement the monitoring?

What other information do we need to make management decisions?

PORE WATER QUALITY ISSUES AND DISCUSSION QUESTIONS

Desired Outcome*: Gather needed information so that key issues can be identified and discussed. Address monitoring questions, establish objectives based on key issues, and begin the prioritization process.*

Facilities and Utilities

1. Is there known or suspected contamination from parking lot runoff?
2. Are there management practices for vehicle wash runoff?
3. Are there stormwater requirements for this park?
4. Do we have documentation of stormwater outfall locations?
5. Do we have documentation of all septic systems and leachfields located on (or adjacent to) parklands?
6. Is there known or suspected contamination (fecal bacteria, nutrients, other) from septics?

Waste and Contaminants

7. What lands have pesticide application?
8. What types of chemicals are used in the park ?
9. Is there documentation/notification of when animal wastes and pesticides are applied to ranch lands?
10. Are there any landfills on park lands?
11. Are there suspected issues with heavy metals in park waters (other than mercury in Tomales Bay)? Are there any historic mines?

Water Quality Monitoring

1. What water quality related technical support is needed to support existing projects?
2. Are there incidences of poor water quality affecting T&E species?
3. What are the priority water resources to monitor for water quality?
4. What other non-NPS monitoring activities are on-going? SWAMP sites, USGS, UC, Department of Health, County…?

Management Practices (Corrective Actions)

10. What management practices (BMPs) related to water quality are currently being implemented?
11. What are the restrictions to implementation?
12. What construction BMPs are required of contractors and park work?

PRESIDIO WATER QUALITY PLANNING MEETING DISCUSSION

Desired Outcome*: Gather needed information so that key issues can be identified and discussed.*

Land Use & Natural Resources (sources of fecal coliforms and nutrients)

7. Where are equestrian operations located within park watersheds?
8. What are the major sources of sediment (is sediment an issue?)
9. What and where are the major sources of bacteria and nutrients?

Facilities & Utilities

13. Where are the stormwater outfalls and their drainage basins?
14. Is there known or suspected contamination from sewer systems or storm drain overflows?
15. Is there known or suspected contamination (fecal bacteria, nutrients, MBAS) from septics?
16. To where do the parking lots drain?
17. Is there known or suspected contamination from parking lots?
18. Where are vehicles washed?

Waste and Contaminants

12. What is the chemical application policy?
13. What lands have pesticide application?
14. What types of chemicals are used in the park (include name and purpose)?
15. Where are hazardous wastes stored?
16. Are there any landfills on park lands? Where and what type?
17. Are there suspected issues with heavy metals in water?

Management Practices (Corrective Actions)

13. What management practices (BMPs) related to water quality are currently being implemented? (e.g., stormwater management practices, agricultural management practices)
14. Are the management practices effective (do we have data to show this)?
15. Are there other management practices that we want to implement but have not?
16. What are the restrictions to implementation?
17. What construction water quality BMPs have been developed?
18. What construction BMPs are required of contractors and park work?
19. Are there watershed management plans (NPS or outside agencies)?
20. Have special protection areas within watersheds been established?
21. Has the park worked with other agencies (e.g., Regional Water Quality Control Board, UC Extension) to establish management practices?

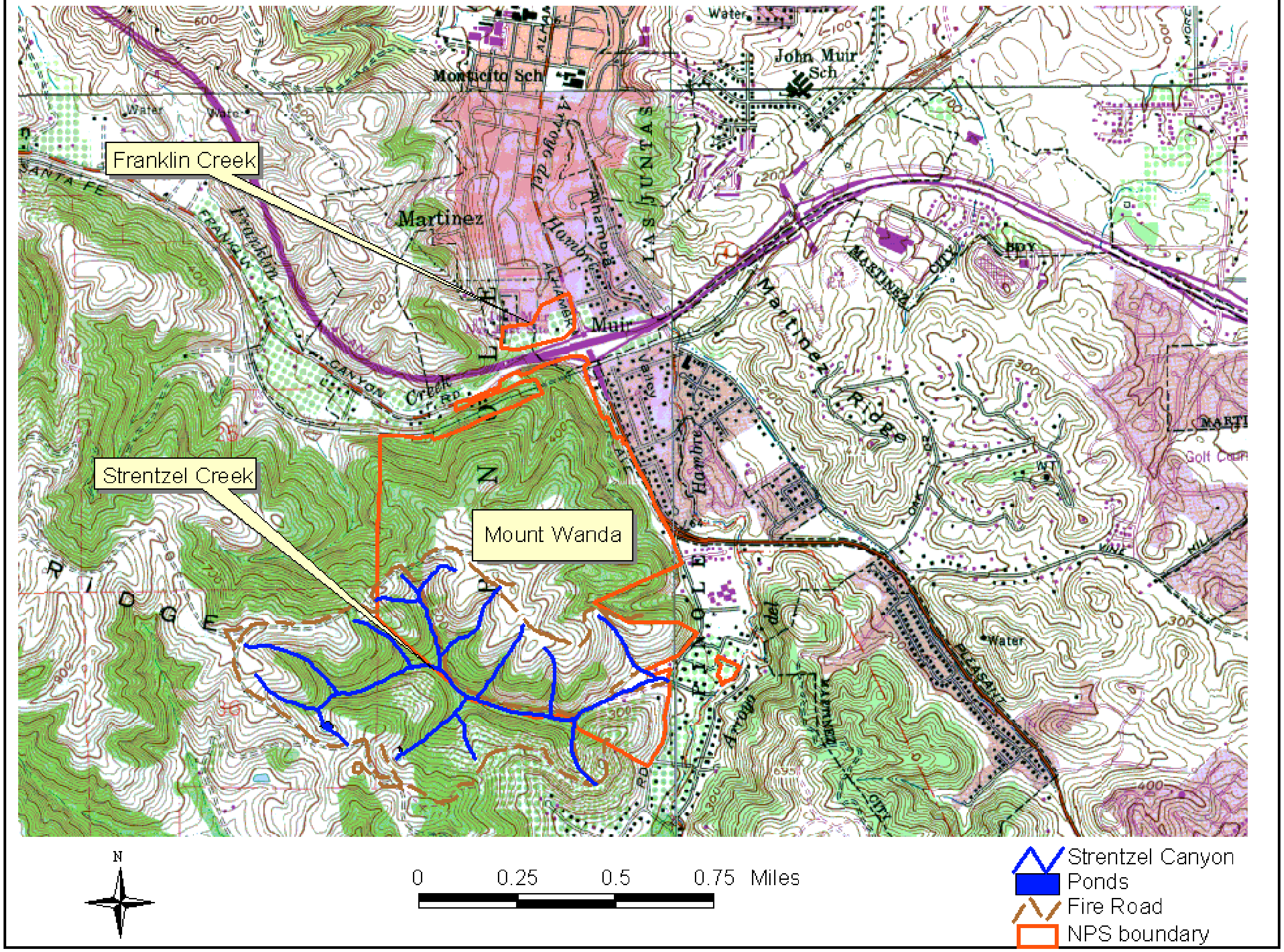
Water Quality Monitoring

6. What types of monitoring efforts are on-going or have occurred in park watersheds?
7. What WQ data (technical support) is needed to support the existing projects or monitoring efforts?
8. What information do you need to assist in making management decisions related to water quality?
9. What do you see as the priority water resources to monitor for water quality?
10. What resources are available to implement the monitoring?
11. What do you see as the role of the SFAN Water Quality Monitoring Program in the Presidio?
12. How is current monitoring data being stored and reported? Who manages and who receives the data?

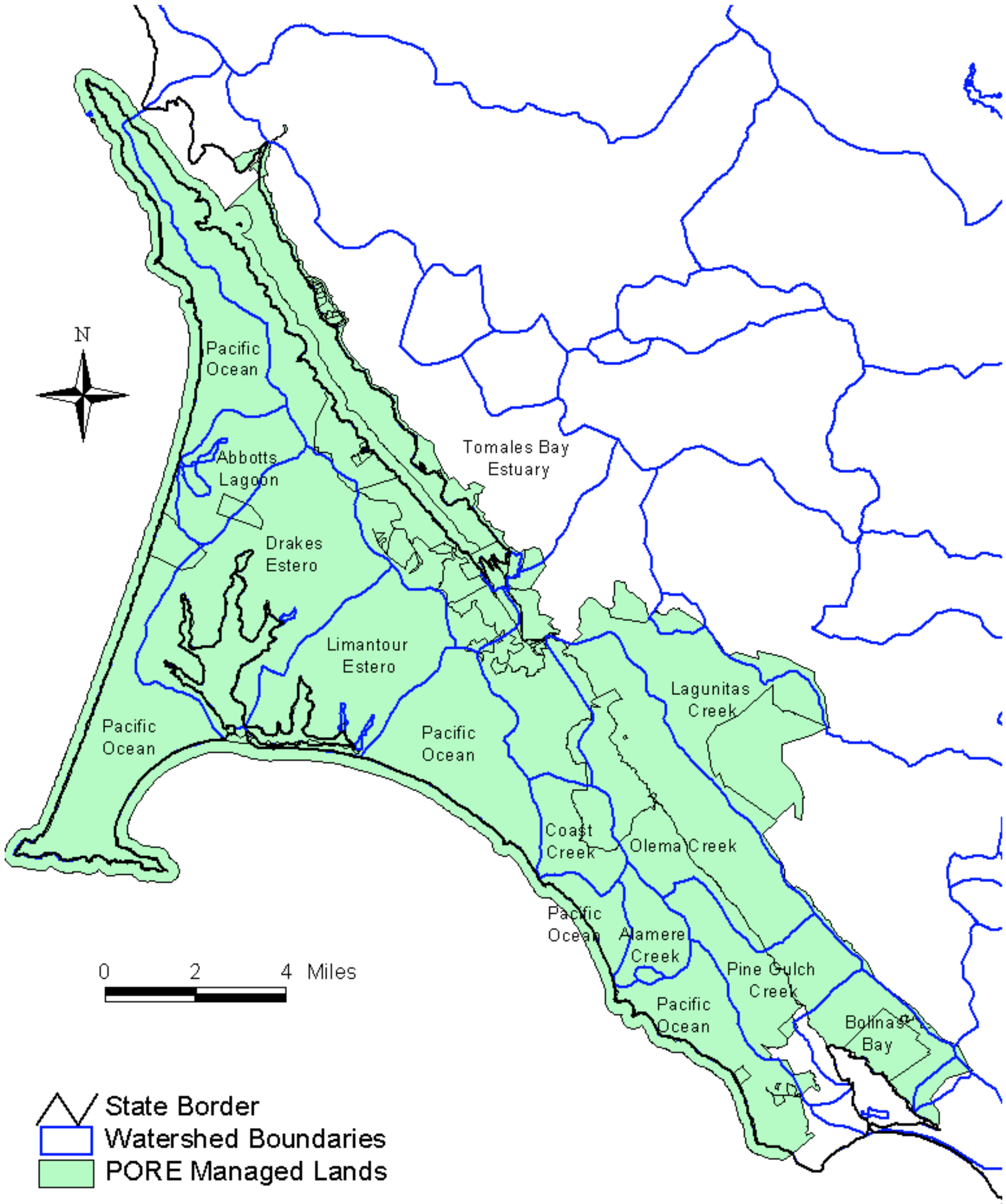
APPENDIX F

Maps of SFAN Watersheds

John Muir NHS and Vicinity

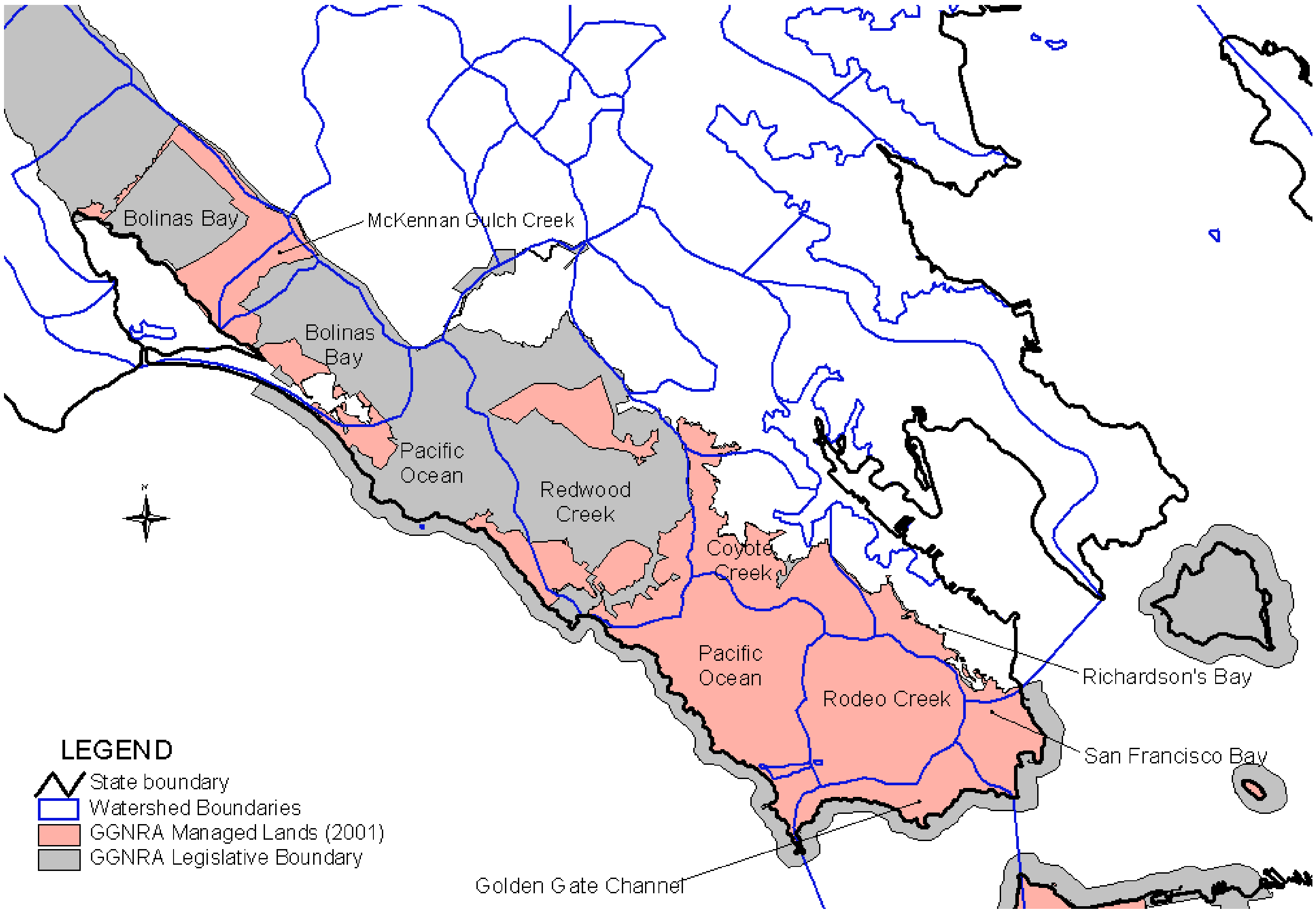


PORE Managed Lands and Watersheds

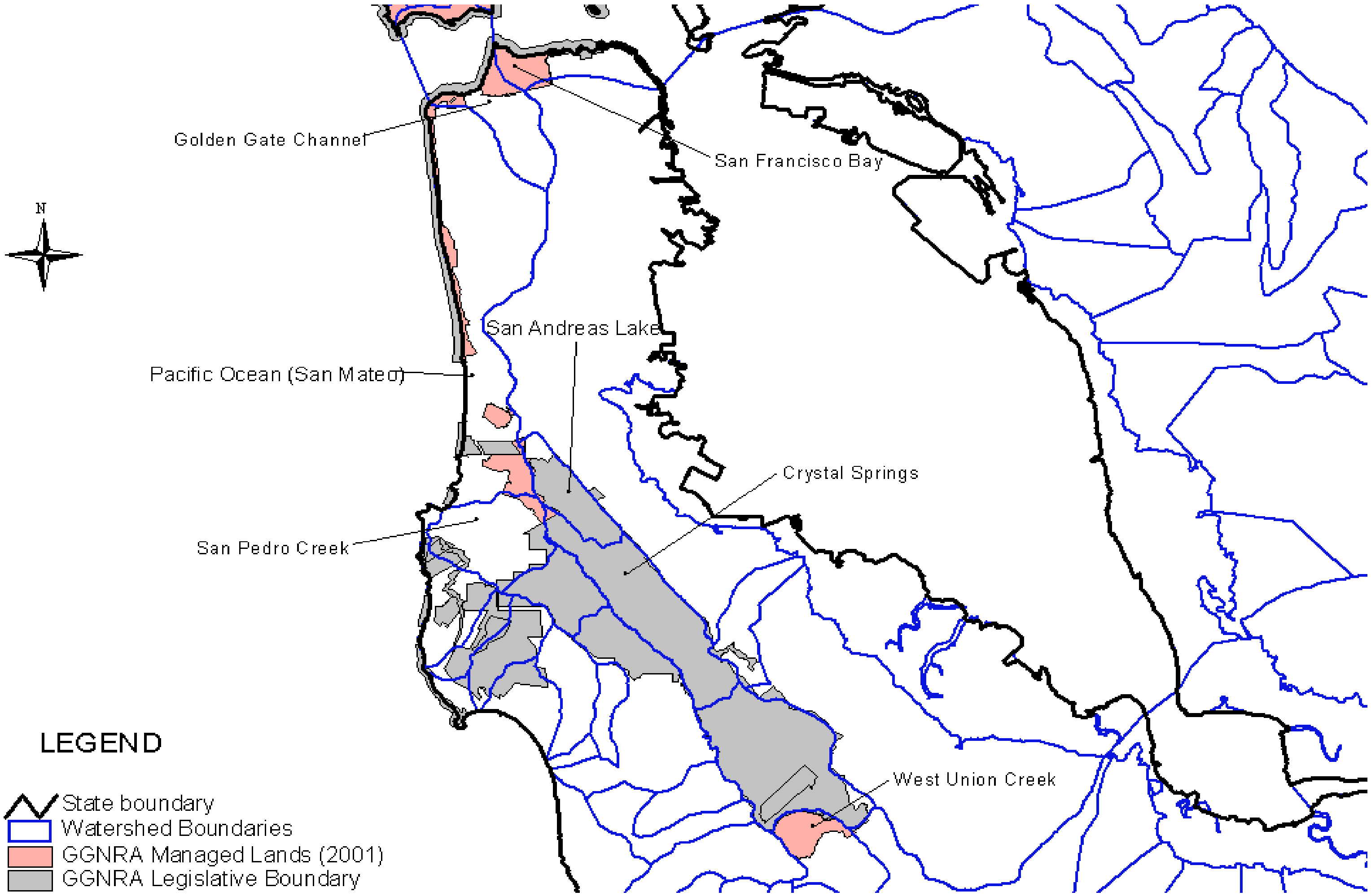


Correction: With the exception of PineGulch, Bolinas Lagoon (“Bay”) Watersheds are managed by GOGA

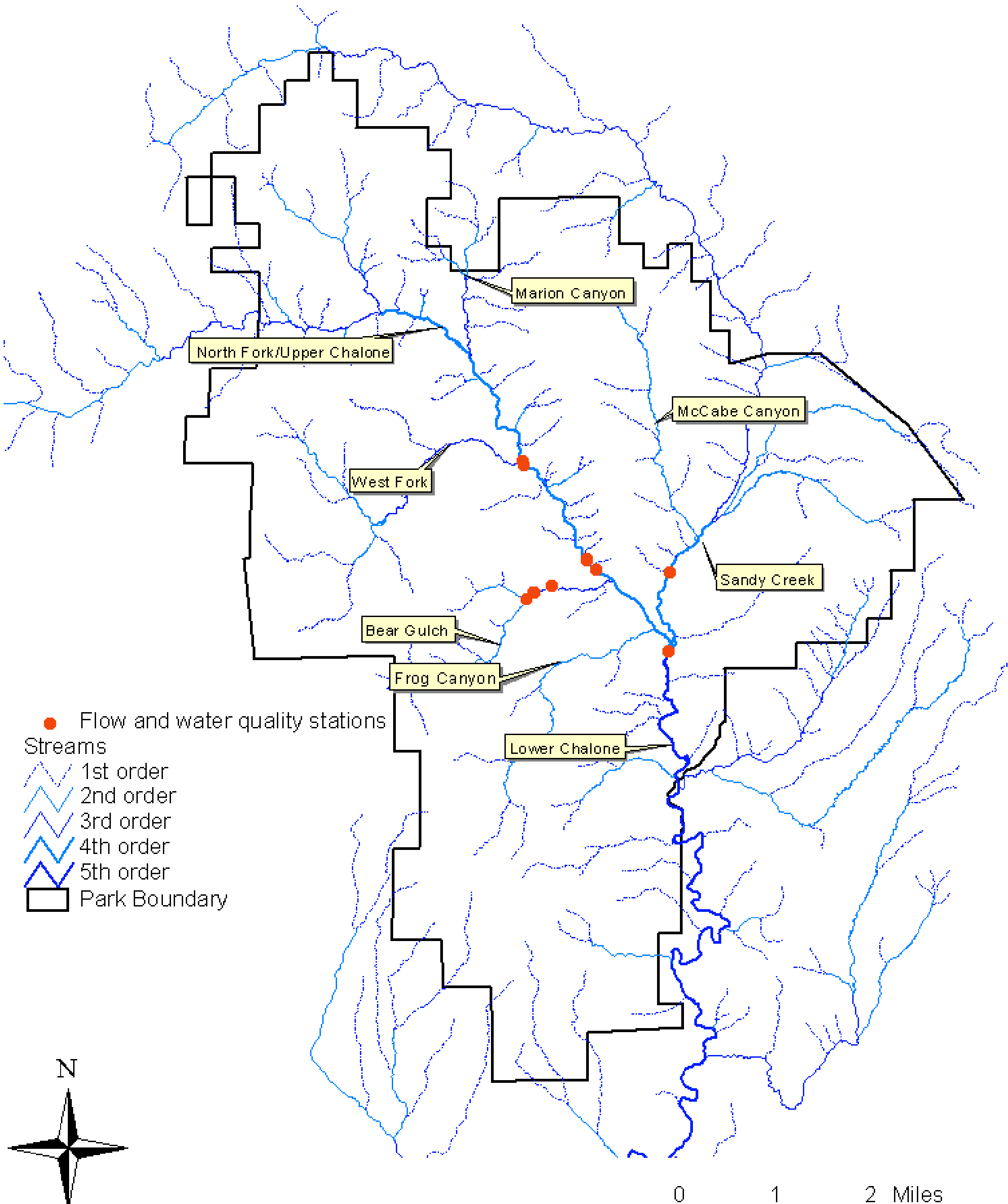
GGNRA Lands and Watersheds (North)



GGNRA Lands and Watersheds (South)



PINNACLES NATIONAL MONUMENT
Chalone Creek Watershed



APPENDIX G

University of California-Berkeley Report

A Review of the Water Quality Monitoring Programs
in the National Parks in Central Coastal California

WQMonitoringReport.pdf